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THE GENERA AND SPECIES OF THE SOUTH AFRICAN FOSSIL APE-MEN

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Transvaal Museum, Pretoria, South Africa

FIVE FIGURES

To the present there have been described from our caves 5 different types of ape-men. First, in 1925, there was described by Professor R. A. Dart the Taungs skull which he named *Australopithecus africanus*. Then in 1936 I described the Sterkfontein ape-man under the name *Australopithecus transvaalensis*, and a little later I placed it in a different genus and called it *Plesianthropus transvaalensis*. Two years later I described the Kromdraai skull under the name *Paranthropus robustus*. In 1947 Dart described an occiput from Makapan under the name *Australopithecus prometheus*; and last year I described the Swartkrans ape-man under the name *Paranthropus crassidens*.

Scientists who are unacquainted with the mode of occurrence of these fossils are naturally inclined to consider that possibly all our ape-men fossils are contemporaneous, and probably all belong to one species. And this opinion has been expressed. If they are contemporaneous, and all have been found in or near the Transvaal, it would seem very probable that all belong to one species. Dr. S. H. Haughton, who recently was Director of the Geological Survey, has indeed expressed the view that all the cave deposits in which the bones have been found are contemporaneous; and Dr. H. B. S. Cooke, formerly Lecturer in Geology in the Witwatersrand University, has stated that he agrees with Haughton.

Dart seems inclined to regard all our forms as species of one genus, and this is the opinion which I believe has been expressed by Professor D. M. S. Watson. Ruggles Gates has recently pointed out that in matters of classification there are always likely to be two attitudes, that of those who incline to lump and that of those who incline to split. He favors dividing modern man into at least 5 species.

Most systematists agree in placing all types of modern man in one species, *Homo sapiens*, but there is a good deal of difference as to how many species of *Homo* are valid. The Heidelberg jaw is called by some *Homo heidelbergensis* and by others *Palaeanthropus heidelbergensis*. Some recognize *Sinanthropus* as a good genus: others consider that Pekin Man is only a species of *Pithecanthropus*. A few go so far as to consider that Java man should be considered a species of *Homo* — *Homo erectus*.

Differences in the classification of the gorillas, the chimpanzees and the orangs are also considerable. And who is to decide which is the better plan? I should like to put the case of the splitter of the South African ape-men as against that of the lumpers.

Australopithecus africanus (Dart). This is the famous Taungs ape-man. The type consists of an excellent skull of a child with the milk dentition fairly well preserved, and with the first upper and lower permanent molars displayed. Though the specimen is well preserved and scarcely crushed at all, it is unfortunately the skull of a child, and some scientists evidently consider that the affinities of a child skull cannot be determined. Hrdlička who examined the skull in 1925 said: "Just what relation this fossil form bears, on the one hand, to the human phylum, and on the other to the chimpanzee and gorilla, can only be properly determined after the specimen is well identified, for which are needed additional and adult specimens." Does this mean that no child skull should be named or its affinities discussed until we get adult specimens?

No other specimens have ever been discovered; and it will be recognized how difficult it is to be sure whether an adult skull found in a different locality belongs to the genus *Australopithecus*. We have little more than the first permanent molars and the shape of the brain to go by. And we cannot be sure of the sex of the child skull.

If we could determine the age of the Taungs deposit and the ages of the other deposits we would have some help as to the contemporaneity or relative ages of the ape-men. But alas, this at present is very difficult to determine. We have a fair knowledge of the mammals associated with the Taungs ape-man. We know at least 14 mammals that were contemporaneous. All the species are extinct as are 4 of the genera. Two of the genera, *Gypsorhynchus* and *Mylomygale*, are not even very closely allied to any living forms. So we may assume as at least probable that the deposit is pretty old, though whether Pliocene or Pleistocene cannot be definitely stated. One statement can however be definitely made, namely that when the Taungs ape-man lived the climate was very arid — perhaps with a rainfall of 6 inches or less.

Plesianthropus transvaalensis (Broom). When in 1936 the adult skull of an ape-man was found at Sterkfontein the question had to be decided: is this an adult of the Taungs child or a distinct species or genus? All we had to compare were the unworn first permanent molars of the child and the worn teeth of the new form, and the brain casts of the two. The Taungs being has a long narrow brain with an index of about 62.4, and is thus extremely dolichocephalic. The Sterkfontein skull has a brain which has an index of about 83.5, or very definitely brachycephalic.

Having only one skull of the Taungs being and for a time only one of the Sterkfontein, dental comparisons did not seem very conclusive. But we had the associated mammal faunas for comparison.

We had a fair idea of the mammalian faunas of both caves and it was interesting to note that not one of the species that occurred at Taungs occurred at Sterkfontein. This is

to a zoologist convincing proof that the two deposits cannot be contemporaneous, as they are only about 200 miles apart. When *Australopithecus* lived at Taungs, South Africa must have been in a dry phase: when the Sterkfontein ape-man lived the conditions were probably more moist than today.

Though we had in 1936 only one adult specimen of the Sterkfontein ape-man for comparison we now have many, and we even have a good knowledge of the milk dentition. The milk canines in the two types resemble each other considerably, but there is one important difference. That of the Sterkfontein type has definitely three cusps. The canine of the Taungs child has apparently only two cusps—a main one and a small posterior. Though the Taungs tooth is a

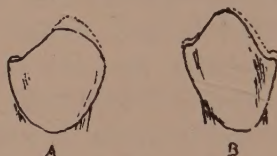


Fig. 1 Lower milk canines (outer view). A., *Australopithecus*, right. B., *Plesianthropus*, left. The dotted lines indicate probable outline before wear. $2\times$ natural size.

little worn it does not seem probable that it could have had a small anterior cusp. Of course we do know how variable the canines may be; but we may feel very certain that such different canines belong at least to different species and there seems considerable probability that they belong to different genera.

We can also compare the deciduous first lower molars. Figure 2 shows this tooth in 5 different higher Primates. First we have what is probably near the ancestral type, seen in *Paranthropus robustus*. There are 5 main cusps and a very marked anterior fovea. Next we have the corresponding tooth in *Australopithecus*. Here the structure of the tooth differs so very markedly that in my opinion *Paranthropus* not only cannot belong to the same genus, but will probably have to be placed in a distinct subfamily. The *Australopithecus*

tooth has two large anterior cusps and two large posterior, and the anterior fovea has been reduced and forced to the side.

In *Plesianthropus* the first lower milk molar is closely similar to that of *Australopithecus*. The cusps agree fairly closely and there is little of an anterior fovea. Man has the same type of first milk molar and though there is considerable variation the essential type is constant. Sometimes, as in the Bushman tooth shown, the agreement with that of *Australopithecus* is close. In other Bushman teeth there is a marked fovea which lies in front of the antero-internal cusp, and the antero-external cusp is large and comes round towards the front of the tooth.

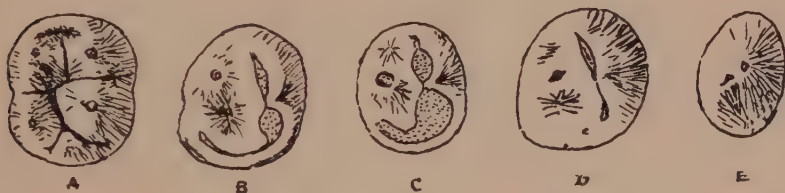


Fig. 2 First right lower deciduous molars in various higher primates.

- A. *Paranthropus robustus* Broom.
- B. *Australopithecus africanus* Dart.
- C. *Plesianthropus transvaalensis* Broom.
- D. *Homo sapiens*.
- E. *Pan* sp. All figures 2 × natural size.

For comparison with these 4 types I have drawn the corresponding tooth in the chimpanzee. Here the structure is so very different that it seems remarkable that there are still those who consider that the ape-men are allied to the higher anthropoids. The chimpanzee tooth is essentially a cutting tooth and not molariform as are the others. There is one main cusp corresponding to the anterior-external, and a small antero-internal, and no posterior cusps and no anterior fovea.

As Hrdlička considered that it was impossible to tell whether the Taungs skull is nearer to the gorilla or to man, it will be manifest that it is difficult to tell whether it belongs to the same genus as the Sterkfontein. Pretty clearly the two forms are allied and specifically distinct. The evidence is not quite strong enough to decide with certainty if they are congeneric. To keep them at present in distinct genera seems wiser than placing them in the one genus.

Paranthropus robustus (Broom). Though the Kromdraai cave deposit is only about two miles from the main Sterkfontein deposit the faunas are quite distinct. The baboons are different, the jackals are different and the dassies are



Fig. 3 Left upper canines, male (inner view). A. *Plesianthropus transvaalensis* Broom. B. *Paranthropus crassidens* Broom. $2\times$ natural size.

different. At Kromdraai horse remains are abundant: at Sterkfontein main cave none have been found. We may thus confidently assert that the ages of the deposits are very different. Most probably the Kromdraai is the later, and it is likely to be Lower Pleistocene.

If the young child jaw which was found within a few feet of the spot where the skull lay belongs as appears to be almost certain to the same species, then we can be quite sure that *Paranthropus* is a very distinct genus from *Plesianthropus*. And having such conclusive evidence from the milk teeth it is unnecessary to discuss the differences of the adult skulls.

Australopithecus prometheus (Dart). At Makapan there have been found in the old mining dump the remains of at least two ape-men. The first specimen found was described by Dart under the name *Australopithecus prometheus*. It is the occiput of apparently a female. Later there was found about half the face of a female which may be part of the same skull. There has also been found much of the mandible of apparently a young male, and also a considerable part of the pelvis which may belong to the same individual as the mandible. While there is no certainty that the jaw belongs to the same species as the female occiput and face it seems probable that it does; and this is also Dart's opinion.

While I am not satisfied with the evidence that these ape-men made fire, I am fully convinced that they belong to a very distinct species. But I consider that they cannot belong to a species of *Australopithecus*.

The deposits at Makapan seem to be of very different age from those at Sterkfontein, Taungs or Kromdraai. At Makapan a whole series of interesting mammals have been discovered which are unknown in our caves of the South. There are a number of Old World monkeys, the most interesting being a short faced form with some resemblances to *Mesopithecus*. The baboons are all unique. Dart considers that two of the baboons belong to species that occur at Sterkfontein. In this I think he is in error. There is evidence of a hipparion which is very much like a Pliocene type, and there is a chalicotherium, which is being described by Miss M. George. There is a rhinoceros and an elephant, a new type of pig, a giant giraffoid and a large number of other new genera and species. The whole fauna is so different from what we know in the South that we seem to be in a new world. We cannot yet decide the age, but I think it will prove to belong to some part of the Pliocene — probably older than the fauna of Sterkfontein — just possibly older than that of Taungs.

It seems unnecessary to discuss the structure of the teeth of the Makapan ape-man when we have one bit of evidence

that seems conclusive that this ape-man is very different from that of Sterkfontein. We have the perfect pelvis of *Plesianthropus* and it has an ischial tuberosity a little like that of the chimpanzee. It possibly was attached to the skin. Fortunately we have the perfect ischial tuberosity of the young Makapan ape-man, and we find it almost exactly as in man. It probably gave attachment as in man to the semi-membranosus, semitendinous and biceps muscles and doubtless over the whole there was the gluteus maximus. It thus



Fig. 4 Outer view of lower half of right os innominatum of *Plesianthropus transvaalensis* Broom. Two-thirds natural size.

seems that the Makapan ape-man was much more nearly human than any of our Southern types. In my opinion the Makapan ape-man belongs to quite a distinct genus, and probably to a distinct subfamily.

Paranthropus crassidens (Broom). At a cave deposit on the farm Swartkrans there seems to be another quite distinct ape-man. Though the deposit is only about a mile from the main Sterkfontein cave the fauna is not only quite different from that at Sterkfontein, it is also different from that at

Kromdraai, and also has no close resemblance to those of Taungs or Makapan. We have a larger species of *Papio* quite unlike anything known elsewhere. We have a new species of *Lycyaena*, a *Hyaenictis* also quite unique, and a new *Felis* allied to the leopard.

The ape-man of the deposit is so common that in a year's work we have found the remains of probably 8 or 10 different individuals. We have a practically complete but considerably



Fig. 5 Crown views of deciduous right lower canine, first molar and second molar.

A. *Paranthropus crassidens* Broom.

B. *Paranthropus robustus* Broom.

C. *Homo sapiens* Bushman, not fullblood. $2\times$ natural size.

crushed skull of a child of perhaps 7 years, 2 fairly complete but very badly crushed adult skulls, 5 lower jaws, 4 snouts and a considerable number of isolated teeth.

The teeth are large and bear more resemblance to those of *Paranthropus robustus* than to those of *Plesianthropus transvaalensis*. I have thus provisionally placed it in the genus *Paranthropus* though I think it must be regarded as a new species. Unfortunately *Paranthropus robustus* is only

known by the type skull and very young child jaw. The first permanent molar in the child jaw is smaller than that of the adult and we may assume as probable that the adult skull is a male. If this is so then the Swartkrans type jaw, which is apparently also male, is pretty certain to be a distinct species as the molars are much larger.

After this paper had been written and on the eve of its being sent off we were fortunate in discovering the nearly complete mandible of a child *Paranthropus crassidens* of probably 6 years of age; and we are thus able to make a satisfactory comparison with the milk teeth of the child of *Paranthropus robustus*. The jaw gives us full knowledge of the structure of the canine and the first and second deciduous molars.

The jaw is remarkably massive for so young a child. In the region of the second milk molar the jaw of this child is as wide as the jaw of the adult Heidelberg man in the region of the second premolar. The teeth are all appreciably larger than those of the child *P. robustus*; but it is probable that the latter is the jaw of a female and this the jaw of a male.

The canine tooth is fully developed but relatively small. It has a rounded rather blunt main cusp and a quite well developed small posterior cusp. Between the two cusps there is a well marked transverse groove. The tooth measures 6.3 mm in anteroposterior length and 4.8 mm in greatest width.

The first deciduous lower molar is present on both sides, but the right one is considerably worn and the left only a little. We thus have the structure much better shown on the left side and it is this tooth which I have drawn reversed. There are 4 main cusps all of about equal size with a small 5th cusp; and there is an anterior fovea with in front of it a small but distinct anterior cusp. The left tooth measures 10.5 mm \times 8.2 mm.

The second deciduous lower molar is a much larger tooth. It has three main outer cusps and two well developed inner. There is a small 6th cusp, and there is a well marked ir-

regular anterior fovea. The right tooth measures 13.7 mm \times 12.3 mm and the left tooth 13.5 mm \times 11.5 mm.

Having thus full knowledge of the lower deciduous dentition of *Paranthropus crassidens*, we see on comparing the teeth with those of *Paranthropus robustus* that the two forms were probably rightly placed in the same genus, and that they are most probably good distinct species, though one jaw we have for comparison is that of a female and the other is that of a male.

A further examination of the dentition of the child *Paranthropus robustus* shows that on the posterior border of the canine there is a very small but distinct posterior cusp. But though the canines of the two species differ in details they are essentially similar and both differ markedly from those of *Plesianthropus transvaalensis*.

The comparison of the first lower deciduous molars in the two species of *Paranthropus* shows again an essential agreement in structure and a definite difference in detail. In both there are 4 sub-equal cusps with a smaller 5th, and in both there is a well marked anterior fovea. In *Paranthropus robustus* the fovea is in the middle of the front of the tooth: in *Paranthropus crassidens* the fovea is a little towards the buccal side. When this tooth is compared with those of *Plesianthropus* and *Australopithecus* it is seen to differ markedly. In these two types the anterior fovea is shifted to the lingual side and partly obliterated by the anterior development of the antero-external cusp which passes forwards and inwards.

The second lower deciduous molar of the two species of *Paranthropus* agree essentially but differ a little in details.

In man the first lower deciduous molar agrees essentially with those of *Plesianthropus* and *Australopithecus* and differs very considerably from those of either of the species of *Paranthropus*. The tooth I figure of a Bush child shows how the anterior fovea is displaced towards the lingual side by the great development of the antero-external cusp.

CONCLUSION

On the present evidence it seems to me we have five species of ape-men belonging to probably four genera, and not improbably belonging to three different subfamilies.

These are:

Sub-family Australopithecinae

Australopithecus africanus

Plesianthropus transvaalensis

Paranthropinae

Paranthropus robustus

Paranthropus crassidens

(?) Archanthropinae

(*Australopithecus*) *prometheus*.

It must be remembered that we have caves which seem to range in age from Upper Pliocene to Upper Pleistocene — a period of probably over a million years. Perhaps the deposits may yet prove to range from Middle Pliocene to recent — a period of several million years. We need thus not be surprised at having found a number of different species and genera of ape-men. I fully expect that in the next 5 or 10 years we shall have doubled the number of species, and within 20 years it is likely that we shall have the complete history of pre-man in South Africa, and the main facts of the evolution which led from a higher Primate to man.

Of course as we get more and more connecting links and have the whole chain from *Australopithecus* to man, classification will become more and more difficult. It will become as impossible to define a species of the ape-man as at present it is to define a species of *Mesohippus* or of some of the Ammonites. We will also be quite unable to say what is ape-man and what is true man. Sir Arthur Keith in discussing this difficulty has suggested that the size of the brain should decide the matter. "I would say that the Rubicon lies somewhere between 700 cc and 800 cc; to be more precise, I would say that any group of the great Primates which has attained a *mean brain volume* of 750 cc and over should no longer be regarded as anthropoid, but as human." Even

this, however, would not get us over our difficulty. Dart's *Australopithecus prometheus* has probably a brain of 800 cm³ in the male, and 700 cm³ in the female. When we get a good male skull I think it likely that many scientists will say, "That is really man;" and some will no doubt go further and say it must be called *Homo prometheus*. The classification of ape-man will be as difficult as that of man is today. There can be no finality. It is only a matter of convenience, and I think it will be much more convenient to split the different varieties into different genera and species than to lump them.



INTERPRETATION OF THE AUSTRALOPITHECINAE.—The combination of limb bones so human in their anatomical details with a brain development scarcely exceeding that of the gorilla or chimpanzee . . . must inevitably raise the question whether the limb bones are correctly to be associated with the fossil remains of the skulls. But the circumstances in which they were found . . . seem to leave no doubt about the correctness of the association. If this is really the case . . ., the conclusions to be drawn are of the greatest significance for the study of human evolution. It must be inferred, for example that in the evolutionary sequence, limbs approximating to a human type had already been acquired at a time when the brain was still of simian proportions. At this phase of development also, the dentition had a definitely human appearance rather than that characteristic of the recent anthropoid apes. The Australopithecine material, indeed, supports the inferences drawn from the indirect evidence of comparative anatomy that many of the diagnostic characters of the recent large anthropoid apes, such as the powerful canines and the large incisors (accompanied by the "simian shelf" in the mandible), the exaggerated development of the supra-orbital torus, and certain features of the hindlimbs, are to be regarded as aberrant specializations peculiar to these apes and not as primitive features to be sought

for in human ancestry. Finally, the morphological evidence of the South African fossils makes it tolerably certain that the point of divergence of the human line of evolutionary development from the line leading to the modern large anthropoid apes must be assigned to a geological date considerably earlier than many palaeontologists have hitherto been prepared to accept.—Statement attributed to Le Gros Clark and reported in “The Pan-African Congress on Prehistory.” *Nature*, vol. 159, 1947, pp. 216-218.

SEMANTIC DIFFICULTIES IN TAXONOMY.—A too fluid conception of taxonomy has been and still is a fertile source of misinterpretation. In fact, it would seem desirable, in any event at the present state of our knowledge, to restrict the application of such terms as “hominid,” “anthropoid,” and “monkey,” to those actual fossils (and conceptual ancestors) that really meet the chief criteria needed for admission to any of these living groups — although I admit the difficulty of gaining universal acceptance of such criteria. All fossils that are clearly transitional or ambiguous in character would automatically be denied the use of such terms; and they could well be given new ones, even though these might be only temporary. Here I have in mind such forms, at the moment of uncertain status, as *Parapithecus*, *Propliopithecus*, *Gigantopithecus*, the Australopithecinae, and the Early Miocene primates of East Africa. I make this suggestion in no spirit of frivolity, and I do so at the risk of being labelled an unmigated “splitter” by taxonomists. But in view of our current semantic difficulties, it is obvious that some common ground of definition must be sought.—William L. Straus, Jr. The riddle of man’s ancestry. *Quart. Rev. Biol.*, vol. 24, no. 3, September, 1949, pp. 200-223.

THE EVOLUTIONARY SIGNIFICANCE OF THE PROTOSTYLID

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FOUR FIGURES

Certain cusps have limited and peculiar distributions among the primates. One of the most significant of these is that which has been derived from the anterior portion of the buccal cingulum of the lower molars. This cusp appears in many of the Australopithecinae, in *Meganthropus*, *Sinanthropus*, rarely in most modern man, but in over 30% of the Pima Indians of Arizona. The occurrence of this cusp gives evidence in support of the ideas of Dart, Broom and Keith as to the affinity between these forms. Its irregular distribution however, offers a challenging problem to the geneticist. This paper offers a description of the cusp, an account of its occurrence and a tentative explanation.

DEFINITION OF THE PROTOSTYLID

The term "paramolar cusp" has been applied to any styler or anomalous cusp, supernumerary inclusion or eminence occurring on the buccal surfaces of both upper and lower premolars and molars. The particular cusps restricted to the anterior portion of the buccal surfaces of lower molars (fig. 1) are the subject of this paper. In order to distinguish them from the general group of paramolar cusps they will be referred to as the "protostylids," which is the proper descriptive anatomical term. Also it must be borne in mind that distinctions are made between this structure and analogous paramolar cusps which are found somewhat commonly on the mandibular second and third molars in all populations. These

analogous cusps can be recognized by their occurrence in the latter teeth when such a cusp is absent on the first permanent lower molars. Greve ('19) and De Jonge-Cohen ('47) called attention to the difference between the protostylids, which they termed "mesio-buccal edge-prominencies," and other buccal tubercles. Adloff ('28) disagreed with their contention, but De Jonge presented evidence in his 1947 article which states that the objections of Adloff are conclusively refuted. The evidence consisted of a photograph and description of a

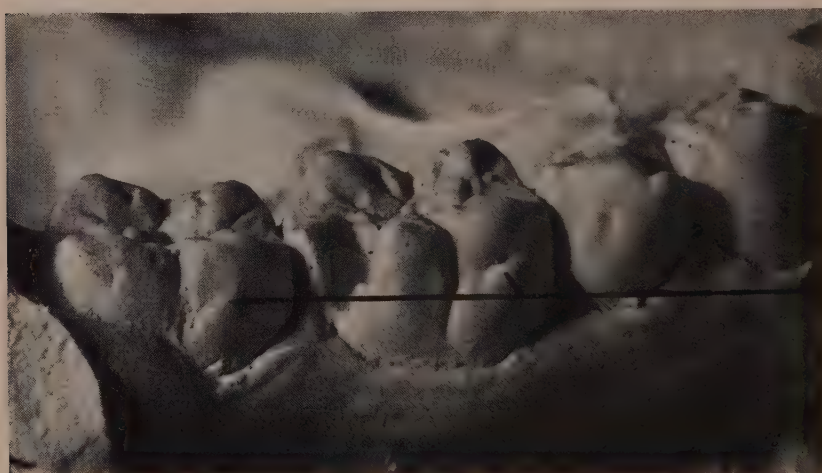


Fig. 1 Lower right molars of female Pima Indian showing protostylids on the buccal surface.

dentition which included both the "mesio-buccal edge-prominency" and a free paramolar II (a supernumerary tooth buccal to and between the lower second and third molars).

The protostylid is closely associated with the buccal groove which separates the protoconid from the hypoconid. It can be described as an elevation or ridge of enamel on the anterior part of the buccal surface of the lower molars, which ascends from the gingival end of the buccal groove and extends mesio-occlusally. It occurs in varying degrees of prominence. The buccal groove is diverted posteriorly in its straight course

from the occlusal surface as it meets the distal part of the cusp. This bending of the inferior portion of the buccal groove is also found in some modern population groups where the groove tends to be prominent despite the absence of the cusp itself (fig. 2). In addition, a pit is frequently found on lower molars at this site. The disto-buccal groove separating the hypoconid and hypoconulid has neither the bend nor the pit.

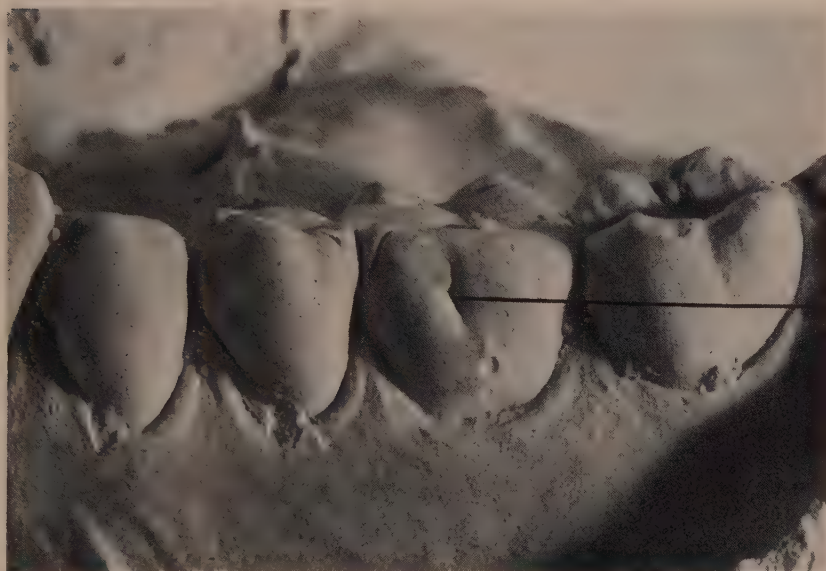


Fig. 2 Buccal surfaces of lower teeth of White female, showing distal deviation of the buccal groove and a pit at the gingival end of the groove on the lower first molar.

DISTRIBUTION IN FOSSIL FORMS

Comment on this cusp in fossil forms has been mainly of a descriptive nature with no attempt to assign it much significance. Dart ('48) described it in *Australopithecus prometheus* as "a laterally disposed enamel ridge." To quote from his article: "This X-shaped appearance of the main furrows is emphasized by the forward extension of the transverse furrow from a pit situated between the anterior and

middle lateral cusps into an anteriorly-running cingular furrow," which "separates a laterally-disposed enamel ridge from the main mass of the antero-external cusp. In *Paranthropus* and *A. africanus* the transverse furrow between the anterior and middle lateral cusps ends laterally in a similar pit between the two cusps but it has no such lengthy forward extension in these forms as that which we find in *A. prometheus*. No account is yet available of the first or second lower molar in *Plesianthropus*, but if the third molar is a fair reflex of the dentition the plesianthropoid type also displayed some evidence of a cingulum in this region."

Dr. Dart's reference to *Paranthropus* and *A. africanus* meant that the "extensions" were present, but not as lengthy or prominent as in *A. prometheus*. This is plainly seen on casts and photographs of the specimens.

Weidenreich ('37) treated its appearance in *Sinanthropus* as an "ascending mesial portion of the cingulum which arises in gorilla to a higher level than its distal portion." It should be pointed out that although the cusp had its origin as an expression of the cingulum, it is a unit structure, an entity in itself and definitely unlike the continuing cingular eminence seen on the gorilla and other anthropoids. In addition it is limited to the anterior portion of the buccal surface. Weidenreich ('45) stated that "The cingulum pattern [of *Meganthropus*] closely resembles that of the *Sinanthropus* teeth nos. 44, 45, 52, 98, 99 and 137."

A cast of Leakey's *Proconsul* seen by the author was not adequate for determining the presence or absence of the protostylid. However, illustrations from photographs show a structure which appears to be it. William K. Gregory, in a personal communication, states that "the large ridge buccal to the protoconid of (of *A. Prometheus*) is evidently homologous with the external cingulum of M_1 M_2 in Leakey's *Proconsul*."

DISTRIBUTION IN MODERN MAN

Prior to a recent phase in the study of the dentition of the Pima Indians of Arizona sponsored by the U. S. Public Health

Service, only 10 instances of the occurrence of the protostylid on the first molars in the modern human population had been reported in the literature. The author ('45) reported finding it bilaterally on the lower first permanent molars on a living White female and in a New Britain Melanesian in the Chicago Natural History Museum collection. Dr. T. D. Stewart (fig. 3) had found it on all 6 lower molars of a New Hebrides Melanesian in the U. S. National Museum collection.



Fig. 3 Occlusal view of the mandibular teeth of a Melanesian, showing protostylids (New Hebrides; United States National Museum no. 227,455, courtesy of Dr. T. D. Stewart, Curator of Physical Anthropology, U. S. National Museum).

Schwarz ('25) reported it on the lower first permanent molars of a Melanesian mandible and in a 6-year-old White boy of Basel, Switzerland. De Jonge-Cohen ('38, '39, '47) reported its presence on the lower first molars of 5 individuals. One has since been found by Dr. Snow on the lower first permanent molar of an Indian Knoll skull (826) of Kentucky, in a sample of 25 specimens providing 49 relatively unworn first molars available for study.

It was therefore quite unexpected when examination of a sample of 80 casts of the Pima Indian population revealed its presence in varying degrees of prominence on the lower permanent first molars of 25 (31%) of the group. Of the 80 individuals 37 had the protostylid on either the lower second deciduous molars (fig. 4), the lower first and second permanent molars or in combination. Fourteen had it bilaterally on the first permanent molars, 4 had it bilaterally



Fig. 4 Teeth of a Pima Indian child, showing protostylid on the buccal surface of the second deciduous lower molar.

on the first and second molars and 7 had it on only one of the first permanent molars.

Most of this group of Indians were children. Consequently, their dentitions included deciduous and permanent teeth. Some individuals had only their deciduous teeth, some had only permanent teeth, and others had some of both sets. Therefore it can be assumed that the figures would be even higher if a full accounting of the molars per individual were available.

Whenever the protostylid was present on the permanent molars it was also found on the deciduous second molars if these teeth were present in the dentition. The reverse was not always true, i.e., its presence on the deciduous molars was not always accompanied by the cusp being on the permanent ones. Twenty-two of the 80 individuals demonstrated it bilaterally on the deciduous second molars and three unilaterally. The occurrence of the protostylid on the deciduous second molars as well as on the permanent molars was to be expected inasmuch as the former retain evolutionarily primitive characters when even the morphologically very stable first permanent molars has lost them. This rule is demonstrated commonly in observations of other dental characters, such as occlusal surface patterns.

RELATED FEATURES IN MODERN MAN

In the description of the protostylid above, it was mentioned that a pit and a distal bending of the buccal groove are frequently found on lower molars of modern populations. Although grooves and occasionally associated pits occur on surfaces of the upper molars, the particular character and location of these elements in the lower molars seem to indicate that they are residual evidences of the existence of the protostylid in man's dentition of the past. In some populations the grooves and pits have apparently specialized, becoming extremely large. Pedersen ('49), in commenting on the very high incidence of exceedingly large and deep pits (foramina caeca) in the East Greenland Eskimo, said "the canal may even be seen to penetrate right to the surface of the dentine, its walls but not its fundus being covered with enamel."

Out of a sample of 22 Pueblo Indians at the Indian School at Albuquerque, 20 had large deep pits at this point on the buccal surfaces of the lower first and second permanent molars. Examination of 25 Apaches at San Carlos revealed the same large pits in all their lower molars. Further sampling of skulls at the Chicago Natural History Museum re-

vealed the same to be true of the other Indian groups. The Melanesians had a high incidence of the pit. The Indian Knoll sample revealed less prominent pits in the main. Some showed only a very slight groove and no pit. In many American Whites the grooves are only faintly present and the pit is absent except for a hardly recognizable stained point. In others they are present in varying degrees and a frequent site for invasion of dental caries.

TENTATIVE EXPLANATION

The protostylid probably is manifested fully in modern man only when particular gene combinations occur which allow expression of this ancestral trait. From the evidence it seems reasonable to assume that the potentialities for the cusp are universally present in modern man, but that certain factors prevent them from developing. Geneticists have demonstrated the reappearance of ancestral patterns in experimental animals. An ancestral character, polydactyly, in the guinea pig has been known to reappear when certain gene combinations occur. By controlled breeding Sewall Wright ('34) studied and demonstrated this phenomenon. The fact that the Pima population seems to be a highly inbred group which has occupied a refuge spot of relative isolation might be an explanation for the high incidence of the cusp among them.

There are two general modes of change or evolution in the dentition. First, there are those primary changes or new characters which occur on all the members of a tooth group: on the incisors as a group, on the canines, on the premolars, on the molars or on a combination of these tooth groups. The second mode of change is of a different nature. It does not as a rule affect all the teeth within an entire tooth group or combination of groups. Changes of this secondary type are expressed on the more variable teeth within one or more of the groups. These "variable" teeth are the upper lateral incisors, the lower central incisors, the second premolars and the third molars, as distinguished from the "stable" teeth,

the upper central incisors, the lower lateral incisors, the canines, the first premolars and the first molars.

If teeth are congenitally missing in a dentition, it is rarely one of the "stable" teeth unless the disturbances have been so great as to have caused the posterior members of the tooth groups to be absent also. The "stable" teeth for the most part still retain the evolutionarily primitive pattern even when in the course of evolution these patterns have been changed in the "variable" ones. The 5-cusped "Y" grooved pattern is found on almost all lower first molars, whereas the second and third molars vary considerably from this in modern man. The primitive pattern of the lower first premolar is well recognized; coefficients of variability in size increase from anterior to posterior in the tooth groups; anomalous cusps rarely appear on the "stable" teeth. Exactly the reverse is true of the upper lateral incisors, the lower central incisors, the second premolars and the third molars. These are the teeth that are involved in instances where anomalies appear or when teeth are missing in the dentition. This general rule is observed in regard to all the gross morphological units of the human dentition.

It is this second type of change, the one which is imposed on the "variable" teeth, and which is the mechanism for the secondary polyisomerism of Gregory ('34) and others, that is involved in the discussion of the protostylid. This cusp, which is so prominently seen on all the molars of *A. prometheus* and less so on the other fossil hominids mentioned above, seems to have undergone changes of this secondary type, appearing in modern man on rare occasions principally on only the first permanent molar or as a vestige.

SUMMARY

The protostylids (mesio-buccal prominencies of De Jonge) are the group of paramolar cusps which are limited to the anterior portion of the buccal surfaces of lower permanent molars and lower deciduous second molars. They are a specialization of the cingulum.

They are significant because of their occurrence in many of the Australopithecinae, in *Meganthropus*, in *Sinanthropus* and in rare instances in modern man. Seemingly residual evidences of the cusp are commonly seen in the form of pits and distal deviations of the gingival end of the buccal groove on modern lower molars. The occurrence of this cusp gives evidence of affinity between these forms.

The protostylid was found in varying degrees of prominence on the lower first permanent molars of 31% of a sample of 80 American Indians of the Pima Reservation in Arizona. Of this sample 37 (46%) had the cusp on either deciduous or permanent molars or both. Eleven additional isolated instances of the cusp's presence on lower first molars of modern man have been reported.

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AGE CHANGES IN TOOTH SURFACES.—A method for the study of the smooth surfaces of teeth by means of optical microscopy of metal-shadowed collodion replicas has been described in previous publications [*Pub. Health Rep.*, vol. 61, p. 697, 1946; p. 1397, 1947]. In these earlier studies it was found that the details visible on such replicas include enamel rod ends, perikymata, scratches, cracks, and representations of various developmental and acquired defects. Observation of several thousand replicas taken from surfaces of extracted teeth selected at random demonstrated clearly that classification of surfaces according to the type and relative amount of structural detail visualized would not only be difficult, but also might be inaccurate. For the present study replicas were taken from the surfaces of teeth classified according to the age of the individuals from whom the teeth were extracted. It became evident that the surfaces of unerupted and recently erupted teeth closely resemble one another, but differ greatly from those of older teeth which have been exposed to attritional and other environmental influences. It also became evident that alterations in surface structure occur with a regularity which definitely can be related to age. . . .

. . . . The first evidence of loss of structural detail occurs on the buccal, labial and lingual surfaces as a weakening of the enamel rod-end pattern. Next, individual rod ends and patches of rod ends begin to disappear, and more slowly the perikymata on the occlusal or incisal portions of surfaces become less pronounced. The last regions to lose their structural detail are the cervical thirds of surfaces.—David B. Scott, Harry Kaplan and Ralph W. G. Wyckoff. Replica studies of changes in tooth surfaces with age. *J. Dent. Res.*, vol. 28, no. 1, 1949, pp. 31-47.

SHORT SHORT LESSON IN SCIENTIFIC WRITING.—G. G. Simpson, in "The Meaning of Evolution," adds the following footnote to a discussion of image-forming eyes:

Some students call these "iconogenetic," but the term is no shorter than "image-forming" and means exactly the same thing to fewer people.

THE POSE OF THE SUBJECT FOR PHOTO- GRAMMETRIC ANTHROPOMETRY, WITH ESPECIAL REFERENCE TO SOMATOTYPING

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SIX FIGURES

INTRODUCTION

The increasing use of the photogrammetric method of anthropometry, both for general purposes and in somatotyping, makes its standardization a matter of great importance and some urgency. The reliability of the technique has been investigated, and shown to be high; but the largest error is that due to the difficulty of posing the subject in precisely the same way on two occasions (Tanner and Weiner, '49). Worse than this, there is as yet no standard pose that all investigators agree to use, and the figures from one posing technique may differ in their mean — that is, systematically — from those from another. Thus the posing errors of the two series combined may not be distributed at random. As an example of this, the differences between our recommended pose and the one used in earlier work are reported in the appendix.

There follows, therefore, an illustrated description of a pose for photogrammetry and somatotyping which we hope will become recognized as standard. It stems from the work of Sheldon; but Sheldon does not give sufficient directions in his book on somatotyping (Sheldon, '40) for another investigator to duplicate his technique, and the poses shown in the book's

illustrations vary somewhat one to another. Hooton ('46, p. 767) reports Sheldon's later technique, which is the parent of that advocated here as the main pose. The reasons for the present recommendations will be discussed after the technique has first been fully presented.

TECHNIQUE OF POSING

Three views are taken, front, side and back. In the front view, there are two slightly different postures, either of which may be preferable in particular circumstances. We shall first describe the three poses recommended for general use, and recommended as the sole standard in somatotyping work. There then follows a description of the "arm-supine" frontal pose.

Standard front-view pose

The subject removes wrist watch, eye glasses, and all jewelry including rings; and if a woman, piles her hair up on top of her head with bobby pins or a hairnet, so it does not obscure the outlines of the neck and shoulders. He or she then steps up onto the turntable facing the investigator, and has the feet first placed in the correct position. On the turntable there is a heelplate, about 3 cm high, and for photogrammetry exactly 10 cm behind the center of rotation of the turntable. Two centimeters to either side of the center of the heelplate is a small plate projecting out from it some 4 cm towards the camera but turned outwards slightly at an angle of 10 degrees from the camera-center of heelplate line. The subject places his heels back against the heelplate with the inside of each heel against the projecting plate and fitting along the 10 degree angle. The insides of his heels are thus separated by just 4 cm and his feet are turned outwards at an angle of 10 degrees each to the camera-center of heelplate line. Three parallel lines at the correct angle painted on either side of the turntable facilitate the posing. (The same objective can be achieved by pasting two inner soles onto the turntable at the 10 degree angles, with the centers of the heels 10 cm apart and

having the subject stand on these; but this technique does not allow the alterations below to be made so expeditiously.) The toes must not be turned out further than 10 degrees, or the minimum ankle diameter in the rear view may not be presented in profile to the camera. In the large majority of subjects the legs will not now touch at any point. This is illustrated in figure 1, which represents a perfectly posed picture except that the feet are a few degrees too everted. In an occasional normal man, some women and children, and some hospital patients, however, the legs *do* touch in this position. If the thighs alone touch at their upper parts, no alteration in leg position is made, but if, as is more usually the case, the knees touch (that is, the skin over the internal femoral epicondyles), the heels are carefully moved apart, each to the same distance from the center line, until the knees *just fail* to touch. Light should just be seen between them, as in figure 2. In some women, this leaves the thighs still touching, but if they are to be separated, the posture becomes so abnormal that we consider it better to let them touch.

Having got the legs correctly placed, the investigator then says: "Now stand up to your full height, as straight as you can, with your arms stiff down your sides, like this —," meanwhile demonstrating the pose. The object of this direction is to get the subject standing as erect as possible, but naturally, with the knees (i.e., quadratus femoris) relaxed and shoulders neither hunched up nor drawn back; but the arms stiffly hyper-extended at the elbows. The direction to assume the military position of attention may be given, but in some subjects it produces stiffness of the whole body instead of just the arms, and time is wasted while the investigator gets the remainder of the muscles relaxed. The chest may also get puffed out. Ordinarily no directions whatever are given as to breathing or positioning the chest; most subjects automatically either continue to breathe normally or else stop in mid-expiration, which latter position is the one wanted. If a deep breath has been taken however, or the chest thrust forward, the subject must be told to relax or forcibly made to do so by the investigator

compressing his chest from front to back with the hands. This may suffice to establish the required position, or the subject may then be stopped in mid-expiration following a few ordinary breaths.

The investigator then makes sure the shoulders are naturally placed and relaxed, putting his hands on top of them or pulling down on the arms if necessary to relax a trapezius pull, or to prevent them being squared backwards. The quadratus femoris is relaxed, likewise the abdominal muscles. The subject's face should be straight towards the camera so that the junction of ear and face is clear on each side. The head should be held with the eyes looking directly forwards, that is neither tilted up nor down; this may be secured by telling the subject to look out at his own height, or to look at the horizon. He should not look at the camera lens, which will be at a much lower level.

The arms are then posed. The elbows are locked in forced hyperextension with the triceps strongly contracted. The arm is inclined outwards from the body so that the upper arm clears the side of the chest; this usually puts the elbow about two inches away from the waist, and the hand 4 inches away from the hip. Occasionally the hand has to be further away than this, but then the distance should be kept to the minimum which allows the upper arm to clear the chest, as increasing the hand-hip distance increases the parallax error in the side view (see Tanner and Weiner, '49). The arm is semi-pronated so that the minimum wrist diameter is exactly presented to the camera: to secure this takes skill and experience on the investigator's part, and patience and attention on the subject's. The fingers are kept together and extended with the thumb along the index finger, and the hand bent inwards at the wrist, so that the fingers point vertically down towards the ground.

The investigator takes a final look at the subject's head, which sometimes gets out of alignment during the posing of the arms, and then the picture is taken.

Side view

The subject is told to keep quite still, and turned round on the turntable into the side view. The left side is the one always photographed. If he inadvertently relaxes his pose during the transition, looks down, bends over or twists round, he should be posed again as already described, standing fully upright, looking at the horizon. The face and neck should be in perfect profile, the shoulders not pulled back or up, the chest not inflated or thrust forward. The abdominal muscles should be relaxed; as a rule nothing need be said about them, but a few subjects hold them tensed and find it hard to relax. The same direction applies to the muscles of the buttocks. The quadratus femoris should be relaxed. The subject should not be leaning forward or backward, either as a whole or from the pelvis.

The whole body and legs should be in perfect profile, as in figure 1, with the two legs exactly aligned so that the right leg does not show at all. This can usually be done by bringing forward and relaxing whichever knee is at first held behind the other. There are some people, however, who find this an exceedingly difficult posture to get into, and a few for whom it is clearly impossible without extensive muscular re-education. The commonest twist appears to be at the pelvis, so that with the pelvis held straight by properly aligned legs, the upper part of the body moves out of profile. If the two legs are allowed to get out of line the buttock, waist, thorax and head can all be lined up in profile. If the perfect pose cannot be achieved, this is the first concession to make: an adequate photographic technique enables the outline of the left leg to be clearly differentiated from that of the right even if they overlap slightly. Much less commonly, ineradicable twisting of the waist occurs, and buttocks, waist and thorax cannot all be simultaneously got into profile. It is then best to sacrifice the profile of the buttock. Occasionally twisting of the neck occurs where face and thorax cannot be aligned; every effort should be made to un-

screw such a subject, but if this proves impossible it is best to keep the thorax in profile.

The arm should be hyperextended at the elbow and locked, with the triceps taut. The hand should be held so that a line down the center of the forearm continues over the wrist straight down the center of the middle finger, and the fingers should be straight, thumb beside index. The arm should be held out from the side as in the front view, so that the upper arm clears the chest, and is not made to flatten out antero-posteriorly by contact against the chest wall or a highly developed *teres major* or *latissimus dorsi*. It should not, however, be inclined outwards more than is strictly necessary. The right arm can almost always be made to disappear entirely in this view; if this proves difficult, sometimes the arm can be hidden by clamping it right against the body, or by putting it into the "arm-supine" position; with care this can be done without distorting the position of the shoulders. In the rare cases where the arm cannot be hidden, it should be brought forward slightly so that the waist measurement is cleared. The hyperextension of the left arm usually enables it to clear the three profile measurements: minimum waist (TT_2), buttock-top of pubic hair (TT_3) and gluteal fold-front of thigh (LTU_1). Every effort should be made, short of altering the pose of the shoulders, as some subjects spontaneously do, to stop the left arm interfering with these measurements. Often a subject does not keep his arm in maximal hyperextension throughout the whole period of posing and it is a good plan for the investigator routinely to tell the subject once more "straighten the arm *right* down," just before he retreats to the side as the picture is taken. Some subjects, however, can extend the elbow very little, despite their best efforts, and if they are also fairly ectomorphic, it becomes impossible for all the three diameters to be simultaneously cleared. (They do not amount to more than 1 or 2% of the population.) The upper leg diameter, LTU_1 , is the one that should then be sacrificed, by allowing the wrist to come forward, preserving the TT_2 and TT_3 outlines. Sometimes by tilting the wrist so that the fingers

point somewhat backward LTU_1 can just be cleared. However, if not, the outline of the thigh can nearly always be accurately drawn in even if partly obscured; the lower abdomen and the curve of the back are not so easily located. The wrist must be carefully placed so that its minimum side-to-side diameter in this view is presented to the camera; in other words, it should be in exact lateral profile, not rotated. Under no circumstances should the elbow be flexed to bring the wrist up above the top of the pubic hair, as this greatly alters the forearm measurement owing to the contraction of the brachio-radialis.

Back view

The subject is again instructed to stand quite still while he is rotated into the rear view. He is again posed as before. The head should be in the correct position (some subjects tend to look down in this view) and the shoulders normally relaxed. The arms are posed as in front view, with the wrist rotated so that its minimum diameter comes exactly into profile, which again takes time and care. The fingers should point vertically downwards. The legs should again be looked at to make sure all the instructions are being faithfully followed, since it is in this view that correctness in this region matters most. The gastrocnemii and the muscles of the buttock should be relaxed.

Arm-supine front view

There are a few objections that can be brought against the front pose described above. It does not show the palm of the hand, which is a very interesting part of the anatomy; and it does not give the carrying angle, which is a factor in the determination of androgyny. (The correlation of the carrying angle and the angles of the hyperextended arm in front and side standard pose are of the order of .6; the details are in the appendix.) An alternative pose which gives both of these is obtained by placing the subject exactly as for the usual front position, and then saying: "Now just turn your hands around, like this," showing him how to supinate without moving the

upper arm more than can possibly be avoided. The position obtained is shown in figure 3: hands directly in line with forearms, thumb maximally abducted, fingers straight and together. The wrist is turned to present its minimal anterior diameter to the camera. Particular care must be taken to get the shoulders relaxed, as in this pose they are often carried backwards by the subject.

Besides the advantages of showing the palm and carrying angle, there is some evidence that the wrist thickness, and perhaps forearm thickness too, can be taken more reliably from this view than from the side. The chief drawback is the changed and unnatural appearance the subject presents in this pose, which makes somatoscopic somatotyping more difficult and confusing, and so less reliable, than with the other pose. The shoulders, in particular, look considerably different and the subject tends to appear less mesomorphic than when his arms are semi-pronated. All the same, anthropometric somatotyping remains unaltered, so provided all somatotyping on such arm-supine pictures is done metrically, this pose does not, in gaining other things, lose the somatotype. On the whole, however, we recommend it as a possible variant rather than a standard pose.

DISCUSSION

There are a few points in connection with this technique that may usefully be made.

1. It is not difficult to pose a subject correctly, but we must emphasize as emphatically as possible that it takes time, care and patience. It also needs a certain amount of training, which must include the measurement of a series of photographs, good and bad. Only by actually measuring photographs, preferably taken by himself, does an investigator come to realize the tiny but all-important defects in technique which can easily pass unnoticed by a poser who has not had the pain of measuring. Our advice to anybody beginning any sort of photogrammetry is this: take pictures of 25 to 50 subjects posed with all the care you can muster, then measure them. Repeat the same experiment again both with the same subjects and with dif-

ferent ones. You should then be reasonably proficient. Pictures taken in a slovenly way may be all right to look at to get general ideas, but are useless both for the technical process of somatotyping and for the biometrical and statistical procedures that begin with photogrammetry.

2. Each subject represents a new problem in posing. Everyone has his own twists and turns. Some subjects know where their limbs are and are easy to pose; others scarcely know whether the hand is pointing forwards or backwards without looking at it, let alone being able to rotate the wrist a degree or two. The difficulty in posing certain people reaches a climax in psychiatric patients, where, for somatotyping, three attempts are made at the correct pose, and the picture taken on the third attempt whatever its success.

3. The reaction of the subject to this posing procedure is itself interesting from the psychological point of view, and, in this sense, the procedure becomes a behavior test. Different people react in different and classifiable ways, and certain groups of patients have astonishingly uniform departures from perfection. If measurement or somatotyping is being done by someone other than the poser, the measurer must have every confidence that any deviations from the ideal pose are due to the subject's inability to pose that way and not to slovenliness on the part of the photographic team.

4. This rigid system of posing does not seem to break down an individual's fundamental postural pattern altogether. Subjects with a lumbar lordosis usually lean their chests further back and their bellies further forward on the direction "stand up as straight as you can." This must be corrected by the poser, but some awkwardness seems always to remain. From it, and still more from the trouble the poser has in getting the standard pose adopted, a great deal can be learned both of habitual posture and of postural control. It seems to us quite likely that these rigidly posed pictures are the best way to begin a study of posture, and should reveal its major disturbances, even if moving pictures and physiological work are needed for the details. Short movies of subjects being posed

by a skilled investigator would be most revealing. The faithfulness with which adults and children reproduce the same posture each time under these constraints, when photographed at 6-monthly or longer intervals is often most astonishing. One gets to recognize a child as easily by the characteristic posture when he steps up onto the turntable as by his face. Comparison of a series of such pictures shows little details, such as the tilt of the head, the curl of the fingers, or the way the little finger is held a trifle over its neighbor, reproduced exactly from one time to the next.

5. Children over the age of five can as a rule be posed by this technique almost as well, and almost as rapidly, as adults. Some younger children can also be satisfactorily posed; our experience is insufficient to say more than this (see fig. 4). The technique seems admirably suited to longitudinal growth study after the first few years.

6. The reason for the careful positioning of the legs in the front and back views is that ratings or measurements of androgyny depend to a considerable degree on the pattern of the space between the legs.

7. The stiff pose of the arm serves two purposes: it enables the arm to clear the body profile diameters in the large majority of cases in the side view, and it brings out the degree of the subject's mesomorphy so that the anthroposcopic somatotyping is made easier.

8. An occasional subject is found who contracts his sternomastoids and/or trapezii in the front view, usually but not always in association with a visible departure from the ideal carriage of his head and shoulders. This increases the transverse neck diameter (NTt) and must be prevented. In the side view, a wrong carriage of the head may alter the minimum antero-posterior neck diameter (NTap) and this also must be guarded against.

9. Vertical and horizontal guide lines should be incorporated on the white background, spaced about as shown in figure 1 or figure 5. They are used for locating horizontals and verticals and not for checking degree of enlargement or the

size of the image, and so do not have to be meticulously accurate. It is also necessary to have, *exactly* in the plane of the center of rotation of the turntable, horizontal pointers *exactly* 1 m or $\frac{1}{2}$ m above one another, and vertical pointers exactly $\frac{1}{2}$ m apart from each other: these are best built into the turntable. These are seen in figure 5; we have found the most satisfactory measuring point to be the crossing of two white ink lines on a black background. These are necessary in checking to see that no distortion of film or enlarging paper has occurred, and in standardizing enlargements.

10. It is most convenient to have two people in the photographic team, one doing the posing and the other working the camera; with the newer photographic arrangements, however, it is not absolutely necessary. The final look at the subject's pose, however, should be taken from some 3 or 4 m away from the subject, to make sure of the profiles. If the Sheldon camera-subject distance of $4\frac{3}{4}$ m is being used the final look can conveniently be taken by the man at the camera, but in photogrammetry that entails a 10-m distance (Tanner and Weiner, '49) the camera-man is too far away and the poser has to step backwards the required distance.

11. It is not intended that photogrammetry should entirely replace anthropometry of the living subject except when time precludes the latter completely. In any case stature and weight must be taken, and it is highly desirable that sitting height and biacromial diameter be added, at least until satisfactory photogrammetric substitutes are found. Next in importance come bicondylar diameters of the humerus and femur, subcutaneous tissue thicknesses and then limb and body circumferences.

SUMMARY

The reliability of the photogrammetric technique of anthropometry has been shown to be high, but the largest error is due to the difficulty of posing a subject in precisely the same way on two occasions, or to the differences in posing technique of two investigators. This paper therefore describes in some detail a standard technique of posing, recommended both

for photogrammetry and somatotyping. Standard positions for front, side and back views are given, following in general the method of Sheldon. A subordinate variant of the front view pose, with the arms fully supinated, is described for use on particular occasions. Illustrations are given of the correct pose in an adult and a $4\frac{3}{4}$ -year-old child, and of the arm-supine pose.

There is a discussion of various points in connection with the techniques including the training of the person who poses the subject, which should include the actual measurement of a considerable number of pictures. For precise photogrammetry there should be horizontal and vertical 1 m and $\frac{1}{2}$ m markers attached to the turntable exactly in the plane of the turntable center, and the heelplate-center distance should be specified: 10 cm is recommended for adults, 8 cm for children under 10. There is an appendix giving the figures for differences in various measurements when taken from this standard pose from a previously used "loose" pose.

It is hoped that the standard pose described in this paper will find general acceptance and thus obviate the loss to research caused by different workers using different procedures.

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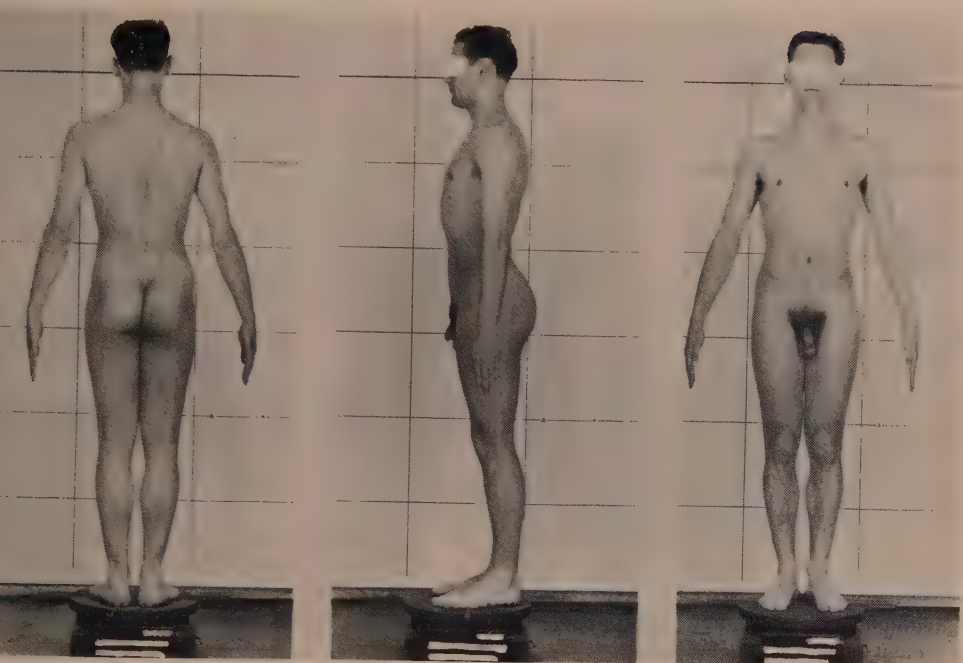
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PLATES

PLATE 1

EXPLANATION OF FIGURES

- 1 A perfectly posed picture except that the feet are a few degrees too everted.
- 2 Heels separated until knees just fail to touch. (The right foot should be slightly more everted, and the wrists slightly turned.)
- 3 Arm-supine front pose. (The heels should be altered to be 4 cm apart.) Note the yardstick in center-of-turntable plane.



1



2



3

PLATE 2

EXPLANATION OF FIGURE

- 4 A nearly perfectly posed picture of a child aged 4 years 10 months.
- 5 Improved turntable and background, showing set distance pointers with white cross lines, cross gridded background and designation board.

APPENDIX

Differences between standard pose and "loose" pose

Before the final development of the standard pose described previously, another pose was used both for somatotyping and for photogrammetry. This is the "loose" pose, wherein the subject is *not* told to stand up to his full height, and his arms are *not* rigidly hyperextended in front side or back positions. It is shown in figure 6. Since one of the authors had used this pose in a large series of subjects, a study was made to find the mean differences between measurements taken from it and from the standard pose.

Fifty-six young male subjects were photographed; three pictures were taken in the loose pose, and then immediately afterwards, without the subject leaving the turntable, three pictures in the standard pose. The measurements recommended by Sheldon were taken, with ATL_3 substituted for ATL_2 , ATU_0 for ATU , and with TT_{nip} added, as in the previous publication (Tanner and Weiner, '49); the technique was that described there; all the measurements were taken by one person. For each dimension the 56 differences between the loose and the standard pose measurements were calculated, and the mean difference and its standard error. Out of the 18 dimensions considered, there were mean differences significant at the 5% level for only 5. These were TT_1 , TT_{nip} , TB_1 , ATU_0 , and ATL_1 . In table 1 are given the mean Loose-Standard values, both in raw figures on the photographic enlargements and in per cent of the mean value of the dimension considered. In the same table the figures for the standard deviation of the differences for each dimension in per cent of the mean value are also given; and, for comparison, the previously reported figures for two photographs, but using the *same* (loose) pose each time (Tanner and Weiner, '49; table 2, v_{a+b}).

The *systematic differences* between the two poses are relatively slight. Naturally the arm dimensions alter most; the slackening of the triceps in the loose pose decreases the ATU_0 measurement by an average of $1\frac{1}{2}\%$, and the slackening of the elbow extension permits the brachioradialis and the wrist extensors to bulge, to the tune of 2%. The altered curve of the back caused by not standing up straight apparently increases TT_1 slightly but decreases TT_{nip} . TB_1 differs by 1%, being increased in the loose posture. This difference however is largely due to a group of a few individuals, whose arms were pulled outwards and elbows upwards too far in the loose posture, thus moving out their latissimus dorsi insertions and unwarrantedly increasing the TB_1 measurement. When this does not happen, no systematic differences seem to occur.

The variability of the differences between pairs of photographs is naturally greater when one member of the pair differs from the other in posture than when they are the same. The different-pose variability is considerably greater in the neck and some thorax dimensions, but of the same sizes as the same-pose variability in the legs. As in the previous study, the general trend of the figures makes it

TABLE 1
Differences between "loose" and "standard" poses
56 Subjects

DIMENSION	MEAN DIFFERENCE LOOSE-STANDARD	MEAN DIFFERENCE IN PER CENT OF MEAN VALUE	STANDARD DEVIATION OF DIFFERENCE IN PER CENT OF MEAN VALUE	STANDARD DEVIATION OF DIFFERENCE IN PER CENT OF MEAN VALUE, FOR TWO LOOSE POSES; FROM TANNER AND WEINER
	<i>mm</i>			
FB ₁	n.s. ¹		1.03	...
FB ₂	n.s.		1.13	0.90
NTap	n.s.		1.97	0.73
NTt	n.s.		2.15	1.22
TT ₁	+ 0.20	+ 0.75	1.88	1.64
TTn _{ip}	— 0.36	— 1.38	2.24	1.65
TT ₂	n.s.		2.70	2.06
TT ₃	n.s.		1.42	1.16
TB ₁	+ 0.40	+ 0.97	3.09	1.76
TB ₂	n.s.		1.60	0.30
TB ₃	n.s.		0.76	0.69
ATU ₀	— 0.21	— 1.57	2.77	1.93
ATL ₁	+ 0.21	+ 2.03	4.75	3.93
ATL ₃	n.s.		3.14	2.37
LTU ₁	n.s.		1.35	1.55
LTU ₂	n.s.		1.74	1.71
LTL ₁	n.s.		0.86	0.97
LTL ₂	n.s.		1.32	1.82

¹ n.s. = not significant at 5% level. Percentage mean differences associated with these n.s. values are all under $\frac{1}{2}\%$.

clear that the reliability of any given dimension depends more on which dimension is measured than on small differences in posing.

It seems as though conversion of loose posture figures to standard posture ones, where past mistakes in posing makes this desirable, is not too hazardous. Probably only three corrections should be made: ATU₀ increased $1\frac{1}{2}\%$, ATL₁ decreased 2% and TTn_{ip} increased $1\frac{1}{2}\%$.

The change to TT_1 is not as large as may occur for the same dimension between different observers, and is perhaps best ignored. The TB_1 correction should not be applied to each picture; it would be better to correct by eye those particular loose pose cases whose arms have been swung out too far.

Carrying angle. In the arm-supine position the carrying angle of the arm can be obtained photographically quite simply. A point is taken in the center of the cubital fossa so that it is over the place where the two segments meet, and equidistant from the medial and lateral borders. A line is then drawn upwards from here passing up the center of the upper arm so far as this can be determined by eye. (This line often passes exactly through skin angle formed by the anterior axillary fold.) A second line is drawn from the center of the wrist through the cubital fossa point, and the angle between the two lines is measured.

There are two possible approaches to the same end in the standard pose. First, similar lines can be drawn in the side view down the hyperextended arm; second, similar lines can be drawn in the front view.

For 44 young male adults these three angles were measured. In the arm-supine view, the carrying angle averaged 10.2 degrees, with a standard deviation of 5 degrees, and a positively skewed distribution. The range was from 2 degrees to 25 degrees. In the standard pose side view, the relevant angle averaged 6 degrees, σ 4 degrees; and in the standard front view 5 degrees, σ 4 degrees. The correlations between the arm-supine carrying angle and the two others were 0.53, side view, and 0.65 front view. Neither is very high. Evidently the standard pose cannot give an exact equivalent to the carrying angle as it is usually spoken of, though it does provide something somewhat similar. Whether the arm angles in front or side standard poses correlate more or less with androgyny than does the carrying angle remains to be seen.



CONGENITAL DEFECTS.—Recent experiments reported by Gillman, Gilbert and Spence [South African J. Med. Sci., 13: 47–90, 1948] should shed new light on the many unknown physiologic factors which bear on the problem of congenital anomalies. Believing that later

effects of chronic malnutrition were causally related to a metabolic disorder induced by entry of abnormal particles into and by qualitative changes in plasma proteins, these investigators treated female rats with trypan blue because of its plasma albumin-binding properties. A random group of 100 breeding female rats and 25 male rats on normal stock diet were given repeated injections of 1 cm³ of trypan blue at 14-day intervals. Of the 100 females, 11 remained sterile. In a total of 697 offspring born in 118 litters, 19.2% presented gross macroscopic malformations detectable at birth. Malformations such as hydrocephalus, spina bifida, tail defects, eye defects and defects of other systems ranged in decreasing numbers, averaging 1.4 anomalies per rat. Timing of dye injection was extremely significant. In female rats that received injections before conception as well as one additional injection during pregnancy, incidence of abnormal pups was 25%. Mother rats given injections the 7th day before conception as well as on the 7th day of pregnancy had an 80% incidence of abnormal pups. Rats receiving only one injection on the day before conception showed a 25% incidence of abnormal pups. Rats receiving one injection, on the 16th day before conception, gave birth to pups in which jaundice developed within the first three days of life. Among all offspring, high neonatal mortality, reduction in size of litters, low birth weights and a general retardation of postnatal development occurred.

Discoveries concerning the connection between maternal rubella infection and developmental defects in offspring plus previously known similar effects of diet restriction and irradiation in animals and the described work of Gillman and associates with trypan blue open a tremendously important new field for basic research. If, as the experiments of Gillman and associates tend to demonstrate, the effects of trypan blue and, by inference, rubella virus, are not direct effects on the fetus but cause remote preceding metabolic states which subsequently interfere with fetal development, the speculative number of viruses, bacteria and chemicals which may produce such metabolic effects are legion. Additionally, the reported occurrence of congenital deformities from preconception effects of rubella infection and trypan blue definitely reduce the nature-nurture or heredity-environment argument regarding developmental influences to the preconception period, wherein affective metabolic states in the male must also be properly considered. While this does not diminish the absolute importance of gene influences, it most certainly increases the relative importance and scope of environmental factors to be considered in human development.—Editorial, *J. Am. Med. Assn.*, vol. 138, no. 9, October 30, 1948, pp. 653-654.

AN ANTHROPOMETRIC AND CONSTITUTIONAL STUDY OF CHAMPIONSHIP WEIGHT LIFTERS

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FIVE FIGURES

The relation of form to function has been investigated in many different ways. In the special case of the relation of morphology to physical strength a group of championship weight lifters should provide an extreme sample to reveal any correlations that may exist.

A great advantage of using a group of competitive weight lifters for investigating problems of physical strength is that weight lifting contests fulfill the major requirements of a good test. The subjects are strongly motivated to give their best performance. Conditions are highly standardized. Performance can be measured objectively and can be readily correlated with morphological measurements and indices. The study of championship lifters should provide an assemblage of individuals approximating greatest strength potential and to some extent eliminate the problem of evaluating the amount of training the lifter has had.

The study reported below was made possible by a grant from the Viking Fund.

MATERIAL AND METHODS

The subjects studied were entrants in the National A. A. U. Weight Lifting Championships held in Chicago June 28 and

29, 1947. Of a total of 57 lifters who entered the contest 46 were included as subjects. The outstanding lifters in all weight classes were measured.

The measurements used in this study are included in the indices of table 2. All measurements were taken in accordance with Krogman and Snodgrass ('47). *Press distance* is a measurement devised to determine the distance a lifter must push a weight from a position upon the chest to a position overhead. It is obtained by subtracting left nipple height from a measurement of left stylium radiale height when arms are held overhead. *Sitting cervicale height* and *mean sitting acromiale height* are also derived by subtraction. *Mean acromial slope* is derived by subtracting mean acromiale height from cervicale height. Arm lengths are determined by subtraction. Total leg length is derived from measurement of iliospinale height, with deductions for height of head of femur.

Forty-three lifters were photographed in the three positions of the Sheldon ('40) somatotype system. The photographs were somatotyped by Dr. W. H. Sheldon and Dr. W. M. Krogman.

One of the subjects, an outstanding lifter, is an achondroplastic dwarf. He is included in all statistical calculations. Many of the indices as well as measurements for this subject represent extremes in the series.

In order to make understandable the weight lifting performances to which morphological data are related in this study it is necessary to outline the sport of competitive weight lifting. Many types of lifts are officially recognized, but most competition is limited to three rigidly controlled standard lifts. The total of the poundage of these three lifts is the score of the lifter. He must perform each lift in a manner approved by two of the three judges in accordance with specifications to be described below. The lifter is allowed three attempts on each lift. Competition is by weight classes: 123 $\frac{1}{4}$ pound, 132 $\frac{1}{4}$ pound, 148 $\frac{3}{4}$ pound, 165 pound, 181 $\frac{3}{4}$ pound, and heavyweight.

The three lifts are the *two arm press*, *two arm snatch*, and *two arm clean and jerk*. The two arm press is begun with weight held upon the chest above the nipples. The weight is then pushed to arms' length overhead, using the arms and shoulder girdle muscles to provide the force. No bending of the back or knees is allowed. The feet must not be moved during the lift. No jerking motions are allowed. Figure 1 shows three stages of the lift.

The snatch and the clean and jerk are known as the "quick lifts" because of the agility and timing required for their performance. They require great effort from muscles of the

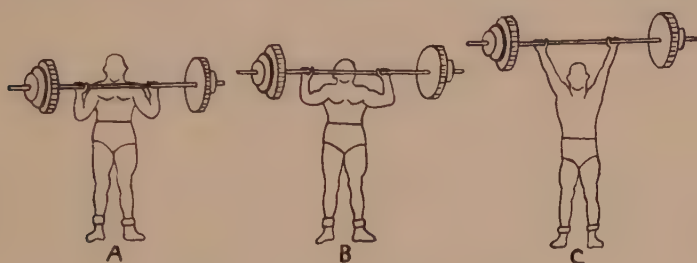


Fig. 1 Two arm military press

- A. Starting position.
- B. Lift in progress.
- C. Completion.

legs, back, shoulder girdle and arms. The high correlation between individual performances of these lifts ($+ .96$) by subjects in this study indicates their close similarity as strength tests.

In the snatch (fig. 2) the weight must be brought from the floor to a position overhead without interruption. This involves pulling the weight as high as possible, then splitting the legs apart fore and aft to get under the weight as it ascends. The arms must lock straight promptly as the weight reaches the height of its ascent. The lifter must then stand upright with the weight held overhead.

The clean and jerk (fig. 3) is accomplished in two phases. The first, the clean, requires the weight to be pulled to the

chest in an uninterrupted motion. The clean is very similar to the previously described snatch, but greater weights can be handled. After the weight is brought to the chest the lifter must stand erect with it, preparatory to the next phase, the jerk. Here the lifter bends his knees, then jumps upward with the weight, throwing it to an overhead position as he once

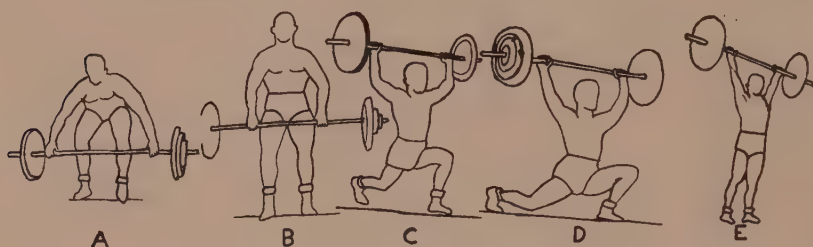


Fig. 2 Two arm snatch

- A. The weight has just left the floor.
- B. The lifter is beginning to pull upward with arms and shoulder girdle. Split will begin before weight reaches chest height.
- C. Lifter splitting, with weight nearly overhead. Both feet are off floor.
- D. Weight at arms' length. Weight must be held overhead in erect position (E) for official completion.

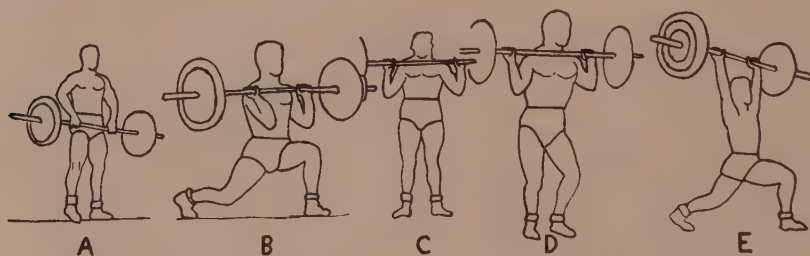


Fig. 3 Two arm clean and jerk

- A. Lifter has pulled weight from floor, is about to split legs apart, leaving floor with both feet.
- B. Completion of the clean, weight secure upon chest.
- C. Erect position assumed, preparatory to performing the jerk.
- D. Knees bent to prepare to drive weight overhead.
- E. Weight overhead. The feet have once more been split apart after both have left the ground. The erect position must be resumed for official completion of the lift.

more splits his legs apart to get under the ascending weight. Once more the upright position must be assumed with the weight held overhead.

RESULTS AND DISCUSSION

Correlation technique was used to try to isolate the influence of different morphological features upon performance

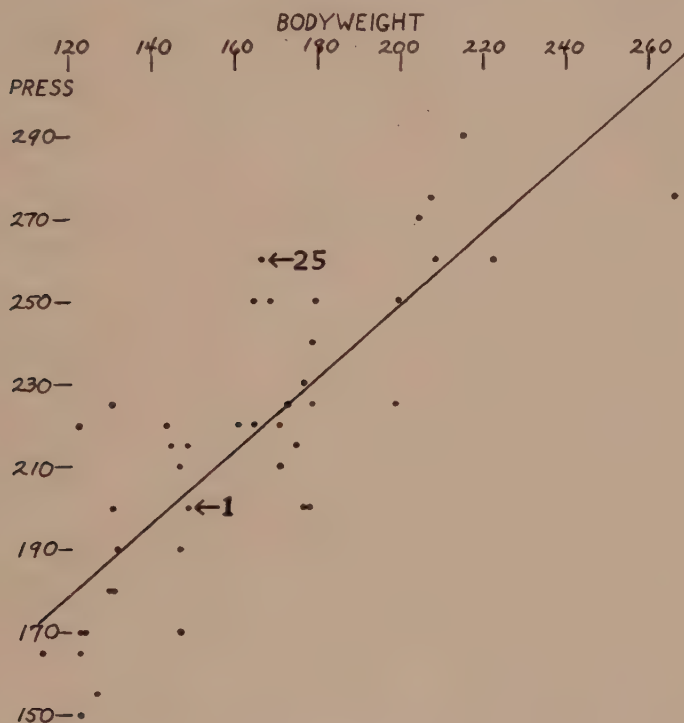


Fig. 4 Scatter diagram showing distribution of body weight and press performance.

in the standard lifts. An obvious initial correlation is that of body weight with each of the three lifts. A high positive correlation of a similar order of magnitude was found in each case. The coefficient for weight and press was $+0.85$; for weight and snatch, $+0.82$; and for weight and clean and jerk, $+0.80$.

Figure 4 shows the scatter of body weight plotted against press performance. The distribution indicates that it gives a linear correlation. The line of regression is drawn.

The line of regression shows an interesting relationship. The ratio of lifting performance to body weight tends to be inversely related to body weight. Thus, in terms of the line of regression for the press, a man weighing 130 pounds can be expected to press 188 pounds, approximately 145% of his body weight. A man weighing 160 pounds can be expected to press 214 pounds, 134% of his body weight. When body weight reaches 200 pounds, the lifter can expect to press only 125% of body weight. The snatch shows a very similar regression: for the same body weights given for the press the percentages are 144%, 133% and 123% respectively. The regression line for clean and jerk follows the same pattern.

It seems certain that this is not a phenomenon caused by selection in the sample. Nearly all the best lifters in the world competed in either the European championships or world championships in 1947. The two top men in each weight class as determined in one contest or the other are included in table 1. In it are calculated the best performances in press, snatch and total, with percentage of body weight lifted. The trend here among the very best lifters in the world, while not absolutely constant, indicates that smaller men can reach a greater peak of relative strength than can larger ones.

Since weight and height are positively correlated, it is necessary to remove the effect of weight to determine the effect of height upon the performance in the various lifts. The first step is to correlate height with weight. The coefficient is $+0.87$ in the sample. The correlation coefficient for height with each of the three lifts is next calculated. These correlation coefficients are as follows: press with height, $+0.65$; snatch with height, $+0.75$; clean and jerk with height, $+0.81$. By using the derived formula for partial correlation of performance in the press and snatch with height with effect of

TABLE 1

Performance of leading weight-lifters in the world in 1947

LIFTER	APPROX. BWT.	PRESS	% OF BWT. LIFTED
Di Pietro, U.S.A.	123	226	184
Asdarov, Russia	123	193	157
Higgins, U.S.A.	132	231	175
Kassianik, Russia	132	215	163
Terlazzo, U.S.A.	148	242	164
Stuart, Canada	148	237	160
Kim, Korea	165	264	160
Stanczyk, U.S.A.	165	259	157
Novak, Russia	181	306	169
Terpak, U.S.A.	181	253	140
Davis, U.S.A.	215	309	144
Kutsenko, Russia	250	298	119

LIFTER	APPROX. BWT.	SNATCH	% OF BWT. LIFTED
Asdarov, Russia	123	198	161
Donskoj, Russia	123	198	161
Fayad, Egypt	132	225	170
Andersen, Sweden	132	220	167
George, U.S.A.	148	242	164
Chams, Egypt	148	242	164
Stanczyk, U.S.A.	165	281	170
Shatov, Russia	165	253	153
Novak, Russia	181	264	146
Vallamo, Finland	181	264	146
Davis, U.S.A.	215	309	144
Schemansky, U.S.A.	204	286	140

LIFTER	APPROX. BWT.	TOTAL	% OF BWT. LIFTED
Di Pietro, U.S.A.	123	661	537
Asdarov, Russia	123	645	524
Fayad, Egypt	132	715	542
Andersen, Sweden	132	704	533
George, U.S.A.	148	771	521
Terlazzo, U.S.A.	148	771	521
Stanczyk, U.S.A.	165	893	541
El Touni, Egypt	165	832	504
Novak, Russia	181	901	498
Terpak, U.S.A.	181	854	472
Davis, U.S.A.	215	1004	467
Kutsenko, Russia	250	953	381

weight removed, the correlation coefficient for press to height is shown to be $-.34$. The coefficient for snatch is $+.14$. With this size sample the coefficient has to be $\pm .30$ to be considered statistically significant. The large difference between the two correlation coefficients, $.48$, indicates that height affects performance on the two lifts in different ways. The significant negative influence upon press indicates that linearity is a negative selection factor in the press, but may be a favorable factor in the snatch. A compact body structure, probably associated with greater muscle mass in the arms and shoulder girdle, is indicated as favoring performance in the press.

The possibly indicated positive effect of linearity upon snatch is supported by the partial correlation coefficient for clean and jerk, $+.37$, a significant figure.

Partial correlation of the three lifts with weight with effect of height removed gives $+.76$ for press, $+.51$ for snatch and $+.34$ for clean and jerk, all above the level of significance. Weight is thus much more important in predicting press than height, is significantly more important for predicting snatch, but is of about the same value for predicting clean and jerk.

The next basic step involves correlation of performance in one lift with performance in each of the other two. The high correlation coefficients are: press to snatch, $+.91$; press to clean and jerk, $+.85$; snatch to clean and jerk, $+.97$. It is indicated that the lifters in the sample tend to have similar ability in all the lifts, but that snatch and clean and jerk performance are more closely related than press performance is related to either. Figure 5 shows the scatter and regression line for snatch and clean and jerk.

In order to attack problems of the correlation of performance to various morphological traits it was necessary to remove the effect of gross size from the calculations. For the morphological element in the calculations this was done by reducing the various measured traits to indices.

The performance element has had effect of weight removed in two ways, creating a double set of correlations of performance to the morphological indices. The first of these

is the calculation of what are here termed performance-weight indices: press-weight index, snatch-weight index and clean and jerk-weight index. These are derived from the regression line formula. Each lifter has an individual press-weight index which shows his deviation in pounds from the

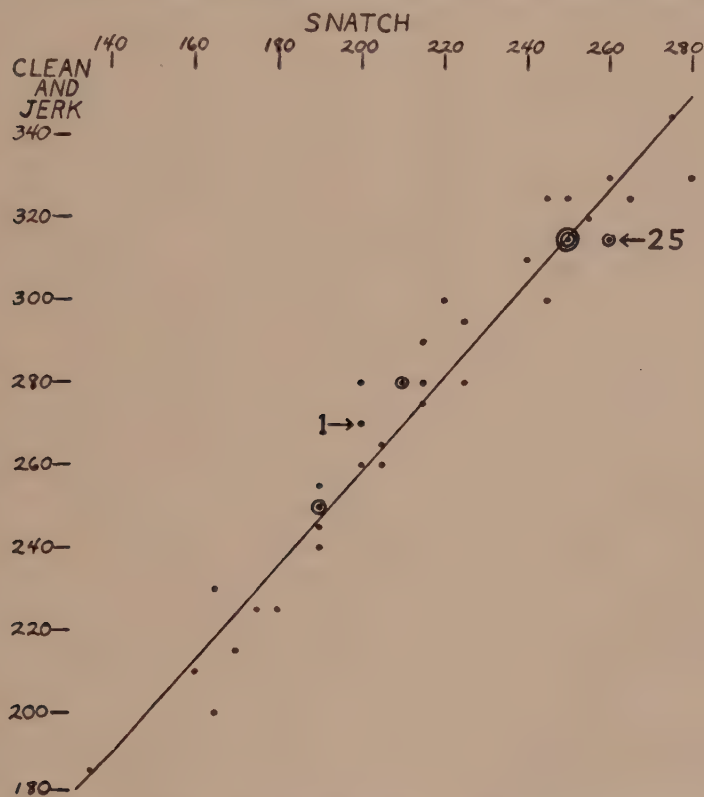


Fig. 5 Scatter diagram showing distribution of snatch performance and clean and jerk performance. Circles around dots indicate duplicate performance.

performance which would be expected of a man of his weight. Snatch-weight index and clean and jerk-weight index are similarly calculated. Reference to figure 4 should make visualization of this quite easy. Lifter number 1, who weighs 148 pounds, should be able to press 204 pounds in terms of the line of regression. His actual performance is 200 pounds,

giving him a press-weight index of -4 . Number 25, weighing 166 pounds, has an expectancy of 220 pounds. His actual performance is 260 pounds, giving him a press-weight index of $+40$.

The second method of eliminating the effect of weight from performance is derived from the press-snatch, press-clean and jerk, and snatch-clean and jerk correlations and their regression lines. Here the deviations from expectancy are in terms of the relationship of the lifts to each other, termed performance-performance indices. Press-snatch index and snatch-clean and jerk index were calculated. The indices are again expressed as deviations in pounds from expectancy. Figure 5 illustrates these deviations in the same manner as figure 4 does for performance weight indices. Here lifter number 1 has snatched 200 pounds. From the line of regression he would be expected to clean and jerk approximately 258 pounds. His actual performance was 270 pounds, giving him a snatch-clean and jerk index of $+12$. Number 25 snatched 260 pounds and could thus be expected to clean and jerk approximately 327 pounds. His actual lift of 315 pounds gives him a snatch-clean and jerk index of -12 .

Performance-weight indices show how the individual lifts relative to the entire sample. Performance-performance indices, on the other hand, relate the individual's performance to his own performance on another lift. Both theoretically eliminate the influence of body weight. If body proportions have a direct influence upon lifting performance, that influence should be shown when indices derived from various measurements are correlated with performance-weight and performance-performance indices. Correlations with performance-weight indices attempt to isolate morphological factors which tend to make individuals conform to group expectancy or deviate from it in a definite direction. Correlations with performance-performance indices, on the other hand, attempt to isolate those morphological traits of the

individual which make him perform in one lift in a manner to be expected from his performance in another lift, or to deviate in a definite direction from expectancy.

The performance indices were correlated with body indices that seemed to promise possibly significant results. The results of these calculations are grouped in table 2. All these correlations are low, but some approach or exceed the level of significance. It appears that skeletal proportions may have some influence on performance in various lifts, but that muscular strength is of enormously greater importance.

Some of the comparisons of body indices with performance-performance indices tend to verify each other sufficiently to indicate that the body indices have a definite influence on the various lifts. Thus index 1 (bi-acromial breadth divided by press distance) gives a correlation with press-weight index of $+.22$, while the correlation with press-snatch index is $-.21$. Since press-snatch index is set up to show snatch expectancy when press performance is the constant, the indication is that press performance is more favorably affected than snatch performance when the lifter's shoulders are wide relative to the approximate distance he must press the weight. Similarly, indices 6 (bi-acromial breadth divided by total arm length), 7 (sitting height divided by total height), 11 (sitting height divided by total leg length) and 15 (chest girth at xiphoid level divided by total height) indicate corroboratively that they are associated with performance in press and snatch. These are verified also by the correlations with snatch-weight index, which indicate by their coefficients approaching zero order that press rather than snatch is favorably affected. The correlations of these same performance indices with index 12 (total arm length divided by total leg length) indicate that both press and snatch are unfavorably affected when the arms are relatively long, but that press is more unfavorably affected.

Analysis of the somatotyping shows that the sample is rated very high in mesomorphy and very low in ectomorphy. Table 3 shows the distribution of each somatotype recorded

TABLE 2

Correlations of performance-weight and performance-performance indices to various body indices

		INDEX				
		Press wt	Snatch wt	C and J wt	Press snatch	Snatch C and J
1.	<u>Biacromial br.</u> Press distance	+ .22	+ .08		— .21	— .32
2.	<u>Biacromial br.</u> Sitting cervicale ht.	— .04			+ .11	
3.	<u>Mean acromial slope</u> Biacromial br.	+ .08	+ .06		+ .03	
4.	<u>Mean sitting acrom. ht.</u> Sitting cervicale ht.	— .07			— .03	— .12
5.	<u>Forearm length</u> Total arm length	+ .01	+ .02		+ .16	+ .29
6.	<u>Biacromial br.</u> Total arm length	+ .39	+ .02		— .27	
7.	<u>Sitting ht.</u> Total ht.	+ .29	+ .13		— .23	— .18
8.	<u>Tibia length</u> Thigh length		+ .05	+ .12	+ .21	
9.	<u>Tibiale ht.</u> Thigh length		+ .01	+ .09	+ .16	+ .33
10.	<u>Sitting cervicale ht.</u> Total leg length		+ .02	— .03	— .23	— .17
11.	<u>Sitting ht.</u> Total leg length	+ .28	+ .07		— .26	
12.	<u>Total arm length</u> Total leg length	— .40	— .24	+ .04	+ .22	+ .53
13.	<u>Chest girth</u> Standing ht.	+ .30	+ .20	+ .01	— .03	— .22
14.	<u>Biacromial br.</u> Total ht.	+ .20	+ .14		— .05	— .07
15.	<u>Chest girth at xi.</u> Total ht.	+ .25	+ .04		— .20	

and gives a breakdown of the distribution of each component. The mode in mesomorphy is at the highest level of the rating scale, while ectomorphy is even more sharply skewed toward a mode at the bottom of the rating scale. The distribution

TABLE 3

<i>Distribution by somatotypes</i>		<i>Distribution of components</i>	
SOMATOTYPE	NUMBER	ENDOMORPHY	
4 - 7 - 1	2	Scale	Number
4 - 6 - 1.5	1	4	3
3.5 - 7 - 1	3	3.5	8
3.5 - 6.5 - 1	3	3	17
3.5 - 6 - 1	1	2.5	7
3.5 - 6 - 1.5	1	2	5
3 - 7 - 1	6	1.5	3
3 - 6.5 - 1.5	3		—
3 - 6.5 - 1	3		43
3 - 6 - 1.5	2	MESOMORPHY	
3 - 6 - 1	2	Scale	Number
3 - 5.5 - 1.5	1	7	17
2.5 - 7 - 1	2	6.5	14
2.5 - 6.5 - 1	3	6	9
2.5 - 5.5 - 2	1	5.5	2
2.5 - 5 - 2	1	5	1
2 - 7 - 1	3		—
2 - 6.5 - 1	1		43
2 - 6 - 1.5	1	ECTOMORPHY	
1.5 - 7 - 1	1	Scale	Number
1.5 - 6.5 - 1	1	2	3
1.5 - 6 - 2	1	1.5	9
—	—	1	31
43	43		—
			43

of endomorphy in the sample approximates a normal curve within the range allowed by the relatively fixed mesomorphy and ectomorphy ratings. It is evident that mesomorphy is positively selected in championship weight lifting, but that any excess in ectomorphy is even more strongly negatively

selective. The endomorphy rating is more difficult to assess, but the indications are that it fluctuates unselectively between the poles of mesomorphy and ectomorphy.

The training methods of weight lifters represent refinements on the discoveries of Siebert ('28) on muscle hypertrophy. The increase in gastrocnemius weight of rats was found to be a function of speed of running rather than duration of the exercise. In rats running at a moderate speed, sufficient to produce slight hypertrophy, conditions soon became stationary no matter how long exercise was continued. Further hypertrophy resulted only when the speed was markedly increased. Weight lifters in training perform repetitions of various exercises with weights, with the emphasis upon heavy weight resistance rather than a large number of repetitions. Space does not permit detailed discussion.

The usual methods for testing strength used by workers in the field of health and physical education are either repetitions of common exercises such as chinning and dipping (McCloy, '31) or measurements of the force exerted upon different types of dynamometers (McCloy, '36). It appears to the writer that both techniques have disadvantages, and that use of adjustable weights in testing can supplement present methods and throw more light upon general problems of strength and fatigue.

Repetition of an exercise to the limit of the individual's strength involves the difficulty of standardizing some of the exercises and brings in problems of motivation and other psychological factors as well as physiological problems of the relation of fatigue to strength. There is also the problem of differences of body weight, a very real one in the light of this investigation.

The suggested use of adjustable bar bell and dumb-bell weights for testing would appear to throw problems of the relationship of strength to fatigue into focus sharply, and be a valuable tool for students of physical education and physiology. A larger number of muscle groups can be isolated for study through the use of such resistance, since a greater

variety of exercises can be performed than with dynamometers or exercises utilizing the resistance of body weight.

As might be expected, this initial investigation of the influence of morphology upon weight lifting performance does not yield many conclusive, positive results. However, it is hoped that the way is to some extent cleared for other workers to use weight lifters and their sport to investigate such problems as those of exercise, strength, fatigue and growth.

SUMMARY AND CONCLUSIONS

1. A group of weight lifters competing in the National A. A. U. Championships were studied by anthropometric and constitutional methods.

2. Strength as measured by lifting performance was highly correlated with body weight in the group. The correlation was apparently linear. The line of regression indicated that the ratio of lifting performance to body weight declines with increasing body weight.

3. Relative linearity affected performance on different lifts to differing degrees. Influence of height with effect of weight removed upon performance was not large in any lift. Influence of weight with effect of height removed varied with the type of lift, but was everywhere significant.

4. The different lifts were highly correlated with each other.

5. Indices of performance relative to weight and of performance in each of the lifts to the other lifts were derived from the respective regression lines. These gave a measure of an individual's performance in terms of deviation from expectancy.

6. The performance indices derived in (5) were correlated with various skeletal indices. Correlations were in all cases low, indicating little or no effect of skeletal proportions upon performance in weight lifting.

7. By the Sheldon somatotyping system all the lifters were grouped well toward the top of the scale in mesomorphy. All

the lifters were toward the bottom of the scale in ectomorphy. Between these polar limits the distribution of endomorphy appeared to be random.

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PHYSICAL ENDURANCE OF THE CHINESE.—Everywhere in China I observed with amazement the loads which men and women carried on their backs, pushed on squeaking wheelbarrows or pulled on rubber-tired carts. On the road between Chentu and Kwanshien huge carts each loaded with at least 3,000 pounds of coal were being drawn by only 5 men and they regularly cover the distance between the two cities, 60 kilometers in three days. On the excursion from Kwanshien to the mountain temples, which was by sedan chair, my respect for Chinese strength and endurance increased still further. The men who carried me were certainly not husky looking and could not have weighed over 130 pounds. Yet when I got off to walk, which I did periodically because of my Western hesitation of being carried, I found that I could not keep up with the procession, moving along at a dog trot, without exerting myself and getting thoroughly drenched with perspiration. This was a very humiliating discovery. After seeing such performances I could not hold my tongue when a foreign doctor in Shanghai tried to tell me that the Chinese were inferior physically.—Magnus I. Gregersen. China as it looked to me. China and America, April-May 1949, 16 pp. (Dr. Gregersen, Dalton Professor of Physiology, Columbia University, went to China last year on a teaching mission for the American Bureau for Medical Aid to China. He and his Chinese research group have recently published "Physiological characteristics of the Chinese" in The Chinese Journal of Physiology, vol. 17, no. 1, 1949, pp. 1-36.)

A STUDY OF THE DIFFERENCES BETWEEN MALE AND FEMALE SKULLS

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TWO FIGURES

The problem of deciding whether a given skull is male or female presents itself under two aspects. Firstly, an opinion may have to be given in the case of an isolated skull not related to any known group. Secondly, a number of skulls may be available belonging to a known group, and the expert is expected to sort these into male and female. In the former instance the problem may be insoluble, or at most represent an uncertain estimation, unless the cranium concerned is an extreme type and shows the masculine or feminine characteristics in a pronounced manner. In the second instance the problem may be comparatively easy, provided something is known of the differential sexual skull characters in that particular human group.

Certain features are said to be characteristic for the male skull, others for the female, and lists of such data are given in all anthropology textbooks. On closer study it becomes clear that many of these statements were based on the examination of insufficient material, and are found to be worthless when sufficient numbers of skulls are investigated. Further, it is generally recognized that considerable differences exist in the various races as regards sexual differentiation, and what may be true for one human group is not necessarily true for another. In view of these difficulties it seemed appropriate to attempt a fresh study of the question of sexual differentiation of skulls in a homogeneous group, viz., the Cape Coloured population, a group which has received little attention from

anthropologists up to the present. It must be made clear from the outset that the conclusions reached will apply to the crania of this particular population group, and are not necessarily correct when dealing with skulls of other races.

MATERIAL

About 65% of the subjects which come to the dissecting room of the Medical School belong to the Cape Coloured population. This group has as its basis the old Hottentot population of the Cape with racial admixture of incoming Europeans and slaves of various Negro tribes. The Cape Coloured population has by now become sufficiently stable to be looked upon as homogeneous, and 50 male and 50 female Cape Coloured skulls of known sex, all adult, were used for this study of sexual differentiation.

PROBLEM AND METHODS

In most textbooks it is stressed that the female skull is nearer to the infantile type than the male skull (Augier, Martin). The masculine skull, as a whole, is larger and heavier; it has more obvious markings for muscle attachments, as seen in the ridges on the squamous part of the occipital bone and in the form of a longer mastoid process. Further, the male skull shows evidence of a more powerful masticatory apparatus, indicated readily by considerable differences in the weights of the mandibles, and by the greater measurements for the total height of the face and higher figures for the total facial index, as compared with the female skull.

Certain cranial vault measurements and indices are said to be significant as pointing to one or other sex. The frontal bone is wider and rises more steeply in the female skull, and as a corollary the parietal bone is less extensive. This observation has been expressed by saying that the female skull inclines to the "frontal type," and the male skull to the "parietal type." A sexual character to which great importance has been attached by some authors (Martin, '28) is the relationship

between the base of the skull and the median sagittal arc of the vault. In the female the nasion-basion distance is said to be relatively smaller when compared with the length of the arc between nasion and opisthion along the median sagittal line; i.e., a considerably lower index is stated to be characteristic for feminine crania. Similar results are claimed when the base of the skull and its maximum length are compared. The special features which are important for sexual identification are listed by Hrdlička ('20) in the following order: the supra-orbital ridges, the mastoid processes, the occipital crest, the mandible, the base of the skull.

Using the above indications given in the literature, I devised a set of measurements which enabled me to test the reliability and respective value of the various methods of sexual identification of skulls. Most of these are well-recognized procedures in physical anthropology, but a few have been planned with the special aim of differentiation of the two sexes. The measurements and the results are shown in table 1. Below are given fuller explanations of some of the headings in the table. (All verticals and horizontals refer to the Frankfort plane.)

Measurements no. 5, 14, 15, 18, 19. These are measurements along various arcs of the cranial vault, and were made with a piece of string laid on the skull between the points indicated; the linear measurement of the piece of string was then noted. Measurement no. 18 is the distance between the porion and a point on the superior temporal line vertically above the external auditory meatus. When the superior temporal line was ill-defined I took a point on the upper limit of the band of roughened bone caused by the attachment of the temporal fascia. Measurement no. 19 was taken along the same line as no. 18, and is the distance between the porion and a point on the sagittal suture vertically above the external auditory meatus.

Depth of infratemporal fossa (no. 16). The depth of the infratemporal fossa was introduced as a measurement because it gives an indication of the thickness of the temporal muscle. With a metal probe one obtains the distance between the upper border of the zygomatic arch and the deepest point in the infratemporal fossa when the probe is directed inwards in a horizontal direction. The point where the probe touches the outer surface of the cranium is on the greater wing of the sphenoid.

TABLE 1

Statistical comparison of male and female skulls of the Cape Coloured population in measurements, indices and special features (measurements in millimeters unless stated otherwise)

	50 MALE SKULLS			σ	50 FEMALE SKULLS			σ	CRITICAL ¹ RATIO OF DIFFER- ENCE
	Range	Mean \pm ϵ			Range	Mean \pm ϵ			
1. Maximum length	168-198	185.6 \pm .9		6.2	165-192	178.6 \pm 1.0		6.9	5.4
2. Length of base	90-110	100.1 \pm .6		4.1	82-106	94.8 \pm .7		4.6	5.8
3. Length of foramen magnum	30-44	36.3 \pm .4		2.9	30-40	34.8 \pm .3		2.4	3.0
4. Maximum breadth	124-150	135.4 \pm .7		4.9	120-146	133.0 \pm .8		5.9	2.2
5. Median sagittal arc	338-410	372.7 \pm 2.1		15.0	332-392	364.3 \pm 2.3		15.8	2.7
6. Basion-bregma height	118-142	131.4 \pm .8		5.3	115-139	127.1 \pm .7		4.8	3.9
7. Horizontal circum- ference	479-542	516.2 \pm 2.1		14.5	465-528	498.3 \pm 2.2		15.6	6.0
8. Cranial capacity (cc ³)	1000-1750	1355 \pm 16.8		117.9	950-1500	1199 \pm 18.1		126.6	6.3
9. Cranial index (4/1)	67.5-80.5	73.5 \pm .4		2.9	68.5-79.5	74.5 \pm .4		2.9	1.7
Height-length index (6/1)	64.5-76.5	70.9 \pm .4		2.5	66.5-75.5	71.3 \pm .4		2.5	.7
Base-maximum length index (2/1)	49.5-57.5	54.0 \pm .3		2.1	46.5-58.5	53.1 \pm .3		2.4	2.1
Base-median sagittal arc index (2/5)	24.1-29.7	26.9 \pm .2		1.4	22.0-29.0	26.1 \pm .2		1.6	2.8
9. Total face height	97-130	116.8 \pm 1.0		7.7	90-120	108.7 \pm 1.2		8.6	5.1
10. Maximum bizygomatic diameter	116-140	128.2 \pm .7		4.7	104-128	119.5 \pm .8		5.5	8.0
Total facial index (9/10)	75.5-105.5	91.0 \pm .9		6.6	75.5-105.5	91.0 \pm .9		6.2	0.0
11. Weight of mandible	40-120g	79.8 \pm 2.6g		18.2	24-88g	60.6 \pm 2.3g		16.4	5.5
12. Angle of mandible	110-140°	125.3 \pm 1.2°		8.2	113-143°	128.0 \pm .9°		6.1	1.8
13. Weight of cranium	390-840g	618.0 \pm 15.2g		106.5	340-840g	572.0 \pm 15.9g		111.8	2.1
14. Nasion to bregma	112-145	129.3 \pm .9		6.6	112-142	126.0 \pm 1.0		7.0	2.5
15. Bregma to lambda	112-136	126.5 \pm .9		6.7	100-145	121.7 \pm 1.3		9.1	3.0
Index, frontal: parietal length (14/15)	83.0-113.0	102.6 \pm .9		6.2	86.0-122.0	103.8 \pm 1.1		7.9	.9

16. Depth of infra-temporal fossa	19-30	24.3 ± .4	2.6	18-29	21.2 ± .3	2.1	6.2
17. Length of mastoid process	21-27	29.3 ± .5	3.6	19-33	26.5 ± .4	3.1	4.4
18. Porion to superior temporal line	75-108	91.9 ± 1.0	7.2	75-99	87.1 ± 1.0	7.0	3.0
19. Porion to vertex	139-163	152.9 ± .9	6.0	124-160	150.0 ± 1.1	7.7	2.2
Index of temporal muscle extent (18/19)	51.0-71.0	60.1 ± .6	4.5	49.0-69.0	57.8 ± .7	4.6	2.5
20. Profile angle at nasion	114-154°	135.3 ± 1.1°	7.9	112-162°	146.6 ± 1.0°	6.7	7.5
21. Supraorbital ridges							
3 categories							
(1) nil or trace	12%			42%			
(2) medium	64%			58%			
(3) marked	24%			0%			
mean score							
22. Occipital crest and nuchal lines		2.12 ± .08	.59		1.58 ± .07	.49	5.0
4 categories							
(1) nil or trace	0%			22%			
(2) medium	54%			66%			
(3) pronounced	36%			12%			
(4) excessive	10%			0%			
mean score							
23. Ridge at upper rim of auditory meatus		2.56 ± .10	.67		1.90 ± .08	.57	5.1
3 categories							
(1) nil or trace	6%			46%			
(2) medium	40%			44%			
(3) marked	54%			10%			
mean score							
		2.48 ± .09	.61		1.64 ± .09	.65	6.5

¹ Critical ratio = $\frac{M_1 - M_2}{\sqrt{\epsilon_1^2 + \epsilon_2^2}}$. (M = mean, ϵ = standard error of the mean.)

Length of mastoid process (no. 17). This measurement is made with the small calipers, as follows: a pencil line is drawn horizontally across the upper part of the mastoid process on a level with the upper border of the external auditory meatus, and the distance is obtained from a point on that line vertically downwards to the tip of the mastoid process.

Profile angle at nasion (no. 20). This angle is the forward angle at the nasion formed by the straight lines joining nasion to glabella and nasion to rhinion. The measurement is made with the help of a piece of plasticine moulded over the nasion region and the nasal bones, as described previously (Keen, '49); the flatter the nasion region the larger will be the angle. The two factors which make the angle smaller are prominent nasal bones and a salient glabella. A prominent glabella is correlated with well marked supra-orbital ridges, and thus the angle at nasion becomes a feature which is useful in sexual differentiation.

Supra-orbital ridges and muscle markings in occipital regions (nos. 21, 22). These skull features, although of considerable importance in sex differentiation, do not lend themselves to measurements which can be expressed as numerical units. Hrdlička ('20) recognized 6 degrees in the prominence of the supra-orbital ridges, viz., "traces," "slight," "moderate," "medium," "pronounced" and "excessive." In this series of skulls I did not find it practicable to use more than three categories to distinguish degrees of prominence of the supra-orbital ridges: (1) "nil or trace"; (2) "medium"; and (3) "marked." It is clear that the Cape Coloured population, as a whole, tend to have rather flat forehead regions, a character which one can attribute to the genetic influence of the Hottentot ancestry.

In estimating muscle markings on the occipital bone (no. 22) one takes into account the prominence of the occipital crest, as well as of the nuchal lines. It was found convenient to recognize 4 categories: (1) "nil or trace"; (2) "medium"; (3) "pronounced" and (4) "excessive." By comparison with 4 skulls set aside, each representing one of the groups, it was easy to assign each of the 100 skulls to the appropriate category.

The external auditory meatus region of the skull. In the literature on sexual differentiation of skulls a certain anatomical criterion connected with the lower border of the external auditory meatus is mentioned by Thiem (1892; see Martin, '28). This author states that the male os tympanicum has a sharp edge along its inferior border which divides to form the sheath of the styloid process, the fossa behind the styloid process (fossa tympanicostylomastoidea) being small. In a woman's skull this sharpened edge does not exist, the lower border of the os tympanicum is rounded and the fossa tympanicostylomastoidea

is larger and shallower. In support of this criterion Thiem quotes the alleged surgical fact that luxation backwards of the mandible occurs only in women. In the present series of Cape Coloured skulls differences in the lower border of the os tympanicum and in the small fossa behind it could be appreciated, but it was not confirmed that a sharp or a rounded border showed a predilection for either sex. Neither is Thiem's claim supported in R. Martin's textbook, where it is stated that "die Existenz einer Fossa tympanicostylomastoidea als Specificum des weiblichen Schädels anzusehen, hat sich nicht bestätigt."

Another anatomical feature in the shaping of the bony meatus, however, did appear to have a definite place among the criteria for distinguishing the sexes, at any rate in the present series of crania, viz., the presence or absence of a bony ridge along the upper border of the external auditory meatus. When making the measurements 18 and 19 which involved finding a fixed point for the porion, the following was observed. In the male skulls there was usually no difficulty in deciding on the position of the porion. In the female skulls, on the contrary, I often had difficulty in fixing the point because there was a smooth transition between the upper wall of the bony meatus and the outer surface of the squamous part of the temporal bone. This difference in the two sexes was appreciated more easily by feeling with the finger than by visual inspection.

The ridge at the upper rim of the external auditory meatus (no. 23 in table 1), with which we are here concerned, is described in osteology textbooks as the posterior root of the zygomatic process. If the ridge is well-marked it will be found to be continuous with the supramastoid crest, which in turn runs upwards into the temporal lines. This skull feature therefore belongs to that group of sexual characters which depend on the masticatory apparatus.

Sometimes the "suprameatal ridge" was absent in a female skull, but nevertheless a small sharp edge was felt due to a prominent suprameatal spine; these two bony ridges should not be confused. As with skull feature no. 21, it was found convenient to choose three categories for no. 23: (1) "absent or trace"; (2) "intermediate" and (3) "marked."

In the three skull features just described (nos. 21, 22, 23) it was found that the categories 1 and 3 or 4 contained a great preponderance of female or male skulls respectively, while the intermediate subdivisions contained skulls of the two sexes in very similar proportions. In spite of the fact that the skulls were grouped into these somewhat arbitrary subdivisions, it was thought justifiable to calculate the mean positions for the masculine and feminine crania (see table 1). Further, the means obtained made it possible to calculate the standard deviations and critical ratios.

DISCUSSION

The critical ratios given in table 1 were obtained by dividing the actual difference between the means by the standard deviation of the differences. A critical ratio of 2.5 is almost certainly significant and can hardly be due to chance factors in grouping. But when the critical ratio exceeds 2.5 the statistical significance of the difference increases proportionately. The male skull, as a whole, is larger than the female one, and the measurements nos. 1-8 all confirm this general observation. Among these, the maximum breadth of the vault has the smallest critical ratio, one which is barely significant. The special importance attributed to the size of the foramen magnum as a distinguishing feature (Martin, '28) is not confirmed in this study of skulls from the Cape Coloured population.

The female skull is said to be more infantile than the male skull. One would expect some indication of this in the cranial index, the infantile type tending towards brachycephaly; but the difference between the means for this index is only slight and almost insignificant. The other three indices with a bearing on the cranial vault (table 1) were equally unhelpful in distinguishing between the sexes. Even the index expressing the relationship between the base of the skull and the median sagittal arc, on which so much stress is laid by other observers (Martin, '28) shows a critical ratio of the difference of only 2.8. In a table (by Bartels; see Martin, '28, p. 740) giving the absolute values of the base of the skull and median sagittal arc measurements in male and female crania, as well as the indices, for 12 different human groups, it is seen that the difference in the index may be considerable, as much as 27.0 for the male, and 20.7 for the female. But in that table there is also one racial group (Malays) where the index shows no difference for practical purposes, viz., 26.8 for male skulls, and 26.7 for female skulls (cf. table 1). The two measurements of the facial part of the skull (nos. 9 and 10) showed high critical ratios of the difference, but I could not confirm the assertion that in men the total facial index is higher than in women (Martin,

'28). Evidently in the Cape Coloured people the total height of the face and the maximum bizygomatic diameter vary in an equal manner, whichever the sex.

The more massive mandible of the male as compared with the female, shown by the weight (no. 11), is very evident, with the high critical ratio of the difference of 5.5. The mean weights of the mandible are given by Augier ('31) as 80 gm in the male and 63 gm in the female; these figures correspond closely to those obtained in the Cape Coloured group (table 1). As regards the angle of the mandible (no. 12) I cannot confirm that it has great value in sexual differentiation, as stated by Hrdlička ('20).

All writers agree that the weight of the mandible varies more from sex to sex than the weight of the cranium (no. 13). The average weight of the cranium in the female is said to be 86% of that of the male, while as regards the mandible, with a more marked disproportion, the female mandible weighs 79% of that of the male (Martin). The corresponding results obtained from the means in table 1 show 92% and 76% for these proportions.

The female skull is said to show a relative preponderance of the frontal bone over the parietal bone, and the male vice versa. Measurements nos. 14 and 15 and an index were introduced in order to test this alleged sexual difference. The absolute measurements nasion-bregma and bregma-lambda showed differences which were in line with the general size of the skulls, but the index gave a negative result. As far as the Cape Coloured population is concerned, we cannot say that the women have crania tending towards a "frontal type," with the male crania tending towards the "parietal type," as appears to be the case in other racial groups.

The two measurements, depth of infratemporal fossa (no. 16) and length of mastoid process (no. 17), are both related to muscular development, although in the case of the mastoid process, as with the supraorbital ridges, other growth factors come into play. The depth of the infratemporal fossa gives an indication of the thickness of the temporal muscle. This varies

considerably in the skulls of the two sexes and is one of the measurements with a critical ratio of more than 6. The increased depth is in part due to the increased dimensions of the male skull in all directions, in part it is achieved by an increased inward curving of the greater wing of the sphenoid, but it is not produced by a relative increase in the outward curve of the zygomatic arch. Otherwise the total facial index, which has the maximum bizygomatic diameter as its denominator, would have shown a difference. Further evidence that the degree of outward curving of the zygomatic arches was the same in the two sexes was obtained by making an analysis of the skulls from the standpoint of the cranial character given in textbooks under the terms phaenozygous and cryptozygous. Among the 50 male skulls, 29 were phaenozygous, 21 cryptozygous; among the 50 female skulls, 23 were phaenozygous, 27 cryptozygous. This difference when analyzed statistically is insignificant.

The next two measurements, porion to superior temporal line (no. 18), porion to vertex (no. 19) and the index concerned, were intended to give a numerical expression to the surface extent of the temporal muscle. The results obtained were hardly more than might be expected with the larger male vault in general, but the index certainly pointed to a relatively more extensive temporal fossa in the male sex.

The profile angle at the nasion (no. 20) showed an extremely high critical ratio of the difference. This can be correlated with the development of the supraorbital ridges which vary in prominence *pari passu* with the glabella, and this in turn influences the profile angle at the nasion. The difference found in this angle at the nasion confirmed the sexual difference and high critical ratio obtained when grouping the skulls into three categories in accordance with the degree of prominence of the supraorbital ridges (no. 21).

Equally successful from the point of view of sexual differentiation were the grouping of the skulls into 4 categories according to the degree of prominence of the occipital crest, of the external occipital protuberance and of the nuchal lines

(no. 22), and lastly their subdivision into three categories using the special configuration at the upper rim of the external auditory meatus as a criterion (no. 23). The occipital bone markings are dependent on the strength of the back of the neck musculature, while the suprameatal ridge is another sign of a powerfully developed temporal muscle.

*Simple method of sexual identification of skulls
belonging to a known population group*

When in possession of sufficient data about the skull measurements separately for the two sexes in a given population group, it is comparatively easy to draw up a simple set of measurements which allows one to identify correctly the sex of each skull with almost 85% certainty. It is necessary, however, to exclude juvenile skulls, because sexual differences are not obvious until after puberty; and also the skulls of very old persons, because senile changes tend to disturb the sexual expression of many skull features.

A certain number of measurements among those with high critical ratios were chosen from table 1, the selection being made on the following basis: (a) the measurements should be simple to make; (b) they should apply to different anatomical regions of the skull; and (c) they should test as far as possible, the various directions along which sexual differentiation is known to occur, e.g., the weight of the mandible was left out, in spite of its high critical ratio of the difference, because the mandible is so often missing and suitable scales are not always available. Further, the development of the masticatory apparatus is being analyzed already under 2 headings out of 7 (see below).

The following measurements were chosen: the maximum length for the vault; the maximum bizygomatic diameter for the facial part of the skull; the depth of the infratemporal fossa; the length of the mastoid process. For these 4 measurements I made use of the mean established for each sex and of the standard deviations, in order to obtain a range character-

istic for the male, another range characteristic for the female skull, and an intermediate "neutral zone" within the standard deviations of each, where the data overlap, e.g., for maximum length, the answer is "probably male" if the measurement is 185 mm or more, "probably female" if it is 178 or less, and uncertain (for which the symbol ? can be used) if the distance for maximum length falls into the range 179-184 mm. The same method is applied to the other measurements selected, giving in each instance three classes into which the particular skull can be placed automatically, according to the numerical value obtained for the measurement.

The anatomical features which appear under the headings: supraorbital ridges, external auditory meatus and the muscle markings on the occipital bone, are so important in sexual differentiation that they must be included in any list of identifying characteristics. From previous knowledge of these features as they present themselves in "typical" male and female skulls of the given population group, a simple inspection is sufficient to make a decision whether a skull is "male," "female" or falls into the uncertain group. Added to the 4 measurements where the "identification" is automatic, we thus have 7 headings each with an answer pointing in one or other direction, or being neutral. When this simple method was applied to 100 crania a correct answer as to sex was obtained in 84 skulls, a wrong answer for 8 skulls, and an uncertain answer for the remainder.

CONCLUSIONS

The existence of crania in which the identification of sex must remain uncertain or may be made wrongly, has been recognized by other writers, particularly Hrdlička ('20). In every lot of skulls we find occasional male crania which are less masculine than the average and tend towards the female type. Similarly there are women's skulls which approach the masculine type in some or in all respects. Just like the soft

parts of the body, the anatomical features of the skull may be subjected to endocrine influences working in the opposite direction from that of the sex indicated by the gonad.

It was stated at the commencement that the problem of sex differentiation of skulls presented itself under two aspects. When the differential skull data of a population group are known, the problem becomes comparatively simple, as has been shown. But with an isolated skull belonging to an unknown human group it is much more difficult to give a reliable opinion as to the sex of the individual. Nevertheless the anatomical criteria listed under 21, 22 and 23 (table 1) will always be valuable, and presumably this applies to the skulls of all racial groups. The other measurements obtained with the calipers will only have a relative value, because the identification depends on a comparison with the ranges and means of the two sexes, data which are not available.

Fortunately it is not often that we have to deal with crania of completely unknown origin, unless it be a fossil find of great antiquity. Usually it will be possible to make a suggestion of racial affinity, and one can utilize known data bearing on that particular group or an allied human group.

SUMMARY

The author reviewed the skull characters which are given in the recognized textbooks as being useful in the differentiation of the sexes. He then devised a set of measurements which could be used to test the efficacy and reliability of these various characteristics, introducing several measurements not usually described. This method of measuring was subsequently applied to a series of 100 adult skulls, 50 male and 50 female. All the crania came from a homogeneous human group, viz., the Cape Coloured population. Calculations of the means and standard deviations in each sex, and of the critical ratios of the differences, made it possible to decide which data were the most valuable in sexual differentiation.

When data of skull measurements, separately for the two sexes, are known in a given population group, it becomes possible to set up a simple method of differential classification. Such a method was applied to the skulls of the Cape Coloured population and gave a correct result in 85% of crania.

ACKNOWLEDGMENT

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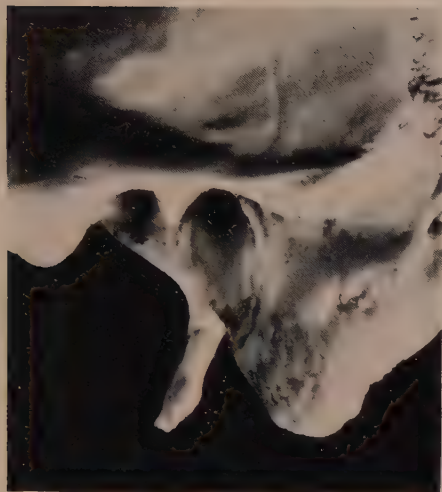


Figure 1

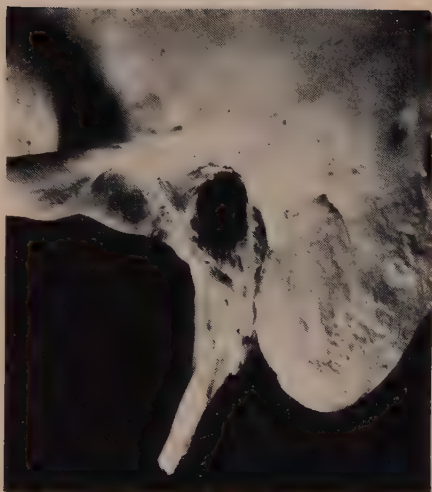


Figure 2

Photographs of the external auditory meatus in two skulls.

- 1 Male skull with "marked" posterior root of the zygomatic process along the upper rim of the external auditory meatus; note the continuity of the ridge with the supramastoid crest.
- 2 Female skull showing only a "trace" of the posterior root of the zygomatic process, and a smooth transition from the posterior part of the meatus to the outer surface of the squamous temporal bone.



CRANIAL CAPACITY BY CALCULATION.—Usually the formula of Isserlis [for calculating cranial capacities] does not require a radical adjustment in order to adapt it to the average L , B and H' measurements for cranial series from different races. The formula was found to make a satisfactory estimate of capacities of several groups of Egyptian and of many groups of Melanesian skulls, and also of Polynesian skulls. For the small series of Hindu and Tamil skulls the averages obtained by direct measurement and formula showed no significant difference.

The formula of Isserlis does not give acceptable results for Australian or Tasmanian male skulls, but the formula of von Bonin, which was worked out on a series of skulls from New Britain, is satisfactory for Australians and Tasmanians of both sexes.

For some series of Mongoloid crania the formula of Isserlis gives capacities in close agreement with the measured capacities, but on the average the Isserlis formula gives a result about 4% too low.

For European skulls the formula of Isserlis gives, on the average, a result that falls short of the measured capacity by about 3%.

On the whole, the evidence indicates that the formula of Isserlis may be cautiously used as a time-saving device, and at least the formula can, sometimes with amendment, be safely employed as a check on experimental work. But no formula can be so trustworthy as careful measurement, and there is a great need for extensive application of well-standardized technique in order to provide more reliable data relating to cranial capacities.—Wilfrid D. Hambly. Cranial capacities, a study in methods. *Fieldiana, Anthropol.*, vol. 36, no. 3, 1947, pp. 25-75.

TORUS PALATINUS

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FIFTEEN FIGURES

INTRODUCTION

Torus palatinus is the bony elevation along the median palatine suture of the hard palate. It has been of considerable interest to anthropologists as well as to dentists and oral surgeons, judging by the numerous publications in these fields. Although the presence of the palatine torus was recognized in the early part of the 19th century, it was first named in 1880 by Kupffer. Fox (1814) first mentioned the torus as an exostosis in the mid-palate region. Carabelli (1842), Kopsch ('11) and others described it as an anatomical variation. Dupley and Follin (1875) regarded the elevation as a defect of conformation. Näcke (1893) included it as one of the stigmata of degeneration found in criminals and the insane. The condition was regarded as an early sign of the tertiary manifestations of syphilis by Chassaignac (1852, 1858). He recorded that his view was opposed by Cullerier and Ricord but supported by Huguier. However, Diday (1850) considered the torus as a natural structure occurring in normal individuals and Richet (1877) reported its occurrence also in young non-luetic women. Martin ('28) regarded it as a post-natal hyperostosis. Herbst and Apffelstaedt ('28) considered the torus to be a characteristic of rachitic palates, but Dorrance ('29) failed to find any relation to rachitis. Horsley ('22) took the lobular form of the palatine torus to be an osteoma and Thoma ('37) believed the larger forms to be true exostoses of the palatal processes.

Stieda (1891) first classified the forms of torus palatinus into two groups: one is broad and flat and the other is narrow and highly arched. Godlee ('09) described bilobular torus and torus of 4 or more lobes. An X-shaped form was reported by Lachmann ('27). Hooton ('46) classified the torus in three forms: ridge, mound and lump. Recently, Miller and Roth ('40) made a classification of the torus based on measurements of its length, breadth and height in the living. No measurements have been reported on dry skulls.

Whether torus palatinus increases in size with advance in age, and whether it has sexual differences, are questions still in dispute. Duckworth and Pain ('00) found "a longitudinal palatine torus" in three crania of Eskimo children. Hooton ('18) also reported its occurrence in three crania of young Icelandic children. Körner ('10) mentioned its rarity among children and its frequency among married women. Its predominance in the female was also found by Lachmann ('27). However, Hrdlička ('40) found a higher percentage of the torus in male "Old Peru" skulls than in female ones. Dorrance ('29) mentioned that the torus has been seen by him in the new-born and that it begins to attain an appreciable size after puberty. Godlee ('09) held that the condition does not appear to increase in size in adults, whereas, on the contrary, Miller and Roth ('40), on the basis of observing a large number of patients, concluded that the torus grows with age and that it is twice as frequent in females as in males.

The racial significance of torus palatinus is also obscure. Kupffer (1880) was the first to consider the torus to be a characteristic of Prussian skulls and Lissauer (1885) supported this view. Kopernicki (1882) and Tarenetsky (1890) reported the condition as a characteristic of Ainu skulls. Waldeyer (1892) mentioned the extreme frequency of the torus in Lapps. Godlee ('09) gave a detailed treatise on the subject and inferred that its presence was concerned with racial characteristics. On the contrary, Hooton ('18) concluded that the condition occurs most frequently in peoples of extreme northern or southern habitat and thus it has no

racial significance. Stieda (1891) made a study of the torus in different races and showed that the condition was not a characteristic of the Prussian skulls but also that it occurred in skulls of other races. According to Stieda, the torus was not of racial significance.

Godlee ('09) did not find any indication of the palatine torus in anthropoids. Martin ('28) also mentioned its absence in anthropoid apes. Van den Broek ('45) could not find the torus in a great number of primates.

Martin ('28) suggested a relationship between the form of the palate and that of torus palatinus.

Relationship of the occurrence of torus palatinus to that of torus mandibularis was suggested by Schreiner ('35) but opposed by Weidenreich ('36), Drenman ('37) and Akabori ('39). Schreiner ('35), Hrdlička ('40) and van den Broek ('45) attributed a causational relation to tori palatinus, maxillaris and mandibularis.

Different interpretations have been given to the causation of torus palatinus. According to Cocchi (1891) the presence, shape and size is dependent upon the palatine glands. Hooton ('18) suggested that this bony elevation is the result of the pressure of mastication. Matthews ('33) and Hrdlička ('40) supported Hooton's theory, whereas Weidenreich ('36) considered torus palatinus to be a primitive hominid character. Recently, van den Broek ('45) attributed its presence to irritation of the mucous membrane of the hard palate.

The present work concerns itself with all these points.

MATERIAL AND METHOD

The adult skulls studied are of 5 series. The Mongolian, American Indian and Eskimo series were obtained from the collections of the U. S. National Museum. The other two series are the American White and American Negro from the Terry Anatomical Collection of Washington University. Pertinent data of age are available in the last two series. There are 93 male and 70 female skulls in the Mongolian series, collected from Urga, Outer Mongolia. The American Indian series is

composed of 96 males and 79 females from different counties of the State of Illinois. The Eskimo skulls were collected from St. Lawrence Island and consist of 193 males and 173 females. The skulls of the other two large series (575 males and 300 females in the American Negro series and 540 males and 127 females in the American White series) are from cadavers received by the Anatomy Department of Washington University. In addition, 102 juvenile crania from Chile and Peru in the collections of the Chicago Natural History Museum and crania of 186 anthropoid apes and of 50 macaques in the collection of the U. S. National Museum were also examined for the palatine torus.

TABLE 1
Scheme for classification of the size of torus palatinus

	ELEVATION	WIDTH	LENGTH
	<i>mm</i>	<i>mm</i>	<i>mm</i>
Small	under 3	under 10	under 15
Medium	3-5	10-15	15-25
Large	above 5	above 15	above 25

The length and breadth of torus palatinus were measured with the sliding caliper and the elevation with the coordinate caliper. The size of the torus was classified as small, medium and large according to the scheme given in table 1. In case any one of the measurements of the torus fails to meet the criteria of the medium or large type, it is classified as of the smaller grade. Thus, if the height of a torus is small but width and length are medium, it is classified as small. However, practically, height proved to be the determining criterion, since all measurements usually agreed with the height.

ANATOMICAL VARIATION VS. PATHOLOGICAL CONDITION

In the present study of 2246 adult skulls in 5 different racial groups, no evidence can be found that torus palatinus is related to syphilis, rachitis or to any other pathological condi-

tion. It behaves wholly as normal bone, and never ulcerates or breaks down. It seems to be a normal anatomical variation and occurs in both youth and age, in both sexes and in all races, though not in the same frequency. When excessively developed, the torus may be an obstruction to speech or to the fitting of a maxillary denture. Only in such cases is a surgical operation sometimes required. In certain pathological cases of the palate, the torus may be involved, but these should not be mistaken as the cause of the torus. It is just like any other normal bony part which may occasionally develop a pathological condition. Figure 1 shows a case of exostosis with very pronounced torus palatinus and also torus maxillaris.

FORM, SIZE AND STRUCTURE

In observation of the palatine torus not only should the bony elevation on the median portion be examined but also the whole surface of the hard palate. The palatal surface is sometimes rather smooth, extremely thin and translucent, and is quite plain near the middle line. It shows only slight indications of crests for the attachment of a part of the tendon of *M. tensor veli palatini*. In some skulls the palatal surface is rather rough and irregular and the crests form prominent wings. On the palatine portion of the palate are two depressions varying much in depth and sharpness of outline, which lodge the mass of glandular tissues. If the two depressions are well marked and meet each other in the mid-line, they appear to form the termination of a median ridge which simulates a weak form of torus palatinus though no true torus is present. Again, if the grooves which lodge the vessels on either side of the palate are deep, the median portion between them resembles to some extent a broad torus, even if it does not actually form one.

The form and size of torus palatinus vary greatly. It may extend anteriorly to the incisive foramen and in rare cases even on both sides of it, and posteriorly to the posterior border of the palate bones. In general it tapers gradually anteriorly, but more abruptly posteriorly opposite the glandular depres-

sions of the palate bones. The torus may be shorter and restricted to a part (mostly middle, sometimes posterior and occasionally anterior) of the palate (figs. 2-4). The width of the torus may occupy as much as two-thirds of the whole width of the palate. The amount of projection also exhibits great variation. In many cases the torus is a uniform, symmetrical, smooth elevation, but it may be found to be on one side only, or one side may have less elevation. Sometimes, it consists of irregular rounded bosses. In certain cases a palate is occupied by two equal elevations running antero-posteriorly, separated by a deep median groove (fig. 5).

TABLE 2

Percentage division of the different forms of torus palatinus found in American White and Negro series

SERIES	SEX	CASES	MOUND	RIDGE	LUMP
American	M	229	74.67	24.89	.44
White	F	56	75.00	23.21	1.79
American	M	208	64.90	34.62	.48
Negro	F	121	61.98	37.19	.83

In the present study the forms of the torus were divided into three types: *ridge* (fig. 6), *mound* (fig. 7) and *lump* (fig. 8). The ridge form is a torus that is relatively narrow and nearly uniform in width from anterior to posterior. A torus that is relatively wide and tapers anteriorly and posteriorly is classified as the mound form. The lump form includes all those tori having masses of irregular shapes.

The percentage distribution of tori according to form in the American White and Negro series is given in table 2. The mound cases are in general the most frequent, and the lump cases the least frequent. The American Whites have a higher percentage of the mound form and a lower one of the ridge form than have the American Negroes. There seems to be no sexual difference in the form of the torus. Table 3 gives the percentages of the various sizes of the torus in both sexes

of the different series. It is seen that the small type is in general the most frequent, the large type the least frequent. The greatest normal length of the torus reaches 50 mm, the breadth 23 mm, and the height 8 mm. Martin ('28) mentioned a torus with an elevation of 12 mm. In the present study, only one torus was found to be as much as 11 mm in height and this case is believed to be the result of exostosis (fig. 1).

A frontal section through the torus is given in figure 9. The torus consists of a thick layer of compact osseous sub-

TABLE 3
Racial and sexual differences in the percentage occurrence of torus palatinus in different series

SERIES	SEX	CASES	SMALL	MEDIUM	LARGE	TOTAL
American	M	575	22.09	11.83	2.09	36.00
Negro	F	298	20.47	14.09	6.04	40.60
American	M	540	26.85	12.78	2.78	42.41
White	F	127	27.56	16.54	3.15	47.24
Mongolian	M	93	38.71	5.38	...	44.09
	F	70	35.71	14.29	...	50.00
American	M	96	44.79	5.21	...	50.00
Indian	F	79	53.16	6.33	...	59.49
Eskimo	M	193	48.19	12.44	2.07	62.69
	F	173	52.02	15.03	2.89	69.94

stance at the oral or inferior surface of the palate. As may be seen from the section it contains a spongy substance in the center and again a layer of compact bone forming the nasal or superior surface. The torus is not produced by a bending downwards of the palatine processes; the floors of the nasal fossae remain either flat or hollowed only to a normal extent. It is essentially a projection downwards of the diploë, though the compact layer on the oral surface varies considerably in thickness. Figure 10 is a microscopic view of a cross section through the middle of a palatine torus. It may be seen that the pressure lamellae are arranged antero-posteriorly,

viz., in a direction from the incisive foramen to the posterior margin of the hard palate. This direction is of interest since it is not in accord with the theory of pressure of mastication which will be discussed later.

AGE CHANGE

Torus palatinus has not been reported to be present in fetal skulls. However, in 20 fetal palates aged from 8 to 9 months, one was found showing an indication of the presence of torus

TABLE 4
*Incidence of torus palatinus in different age groups in the male
American White series*

AGE GROUP	CASES	SMALL		MEDIUM		LARGE		TOTAL	
		no.	%	no.	%	no.	%	no.	%
20-29	7	1	....	0	0	0	0	1	....
30-39	32	6	18.75	5	15.63	1	3.13	12	37.50
40-49	78	26	33.33	8	10.26	2	2.56	36	46.15
50-59	112	32	28.57	16	14.29	5	4.46	53	47.32
60-69	164	45	27.44	20	12.20	4	2.44	70	42.68
70-79	121	32	26.45	17	14.05	2	1.65	51	42.15
80-89	25	3	....	3	....	1	...	7	...
90-99	1	0	0	0	0	0	0	0	0
Total or average	540	145	26.85	69	12.78	15	2.78	229	42.41

palatinus (fig. 11). It is an American Negro female with a C-R length of 325 mm, approximately 34 weeks old.

The presence of the torus in the newborn and in children has been observed by many authors. Among the 102 juvenile crania ranging in age from 1 to 19 years from Chile and Peru, only 19 cases (18.63%) were found with a torus. Though there were no pertinent archaeological data attached to this series, it is believed that they are mostly American Indians, probably with some admixture of white blood. As compared with the results given in table 3, the juvenile series has a much lower percentage of the torus than has the adult series.

Since the males of the American White and Negro series are of sufficient numbers, they were arranged in age groups of 10 years as shown in tables 4 and 5 for the purpose of observing the age change in torus palatinus. It may be seen in both series that in all age groups except those with a very small number of cases the percentages of the torus of the same size have similar values. The general trend seems to indicate that the torus does not increase with age. The total percentages in all age groups are about the same. This holds true for both

TABLE 5
*Incidence of torus palatinus in different age groups in the male
American Negro series*

AGE GROUP	CASES	SMALL		MEDIUM		LARGE		TOTAL	
		no.	%	no.	%	no.	%	no.	%
20-29	84	14	16.67	13	15.48	1	1.19	28	33.33
30-39	109	20	18.35	13	11.93	2	1.83	35	32.11
40-49	116	27	23.28	12	10.34	4	3.45	43	37.07
50-59	107	26	24.30	13	12.15	2	1.87	41	38.32
60-69	95	21	22.11	11	11.58	2	2.11	34	35.79
70-79	49	13	26.53	4	8.16	1	2.04	18	36.73
80-89	13	6	...	2	...	0	0	8	
90-99	2	0	0	0	0	0	0	0	0
Total or average	575	127	22.09	68	11.83	12	2.09	207	36.00

series. It might be expected that if more cases in each age group were observed, the results would be more uniform.

This is contrary to the conclusion derived by Miller and Roth ('40). They stated that "there is a gradual decrease in the number of cases of slight torus as age increases." They pointed out "a gradual increase in the number of moderate cases of torus palatinus with age." "The trend as a whole for marked torus palatinus shows a gradual increase in the number of these cases with an increase in age." Thus, they concluded that torus palatinus appears to grow progressively. However, if we give a critical consideration to the data given by Miller and Roth, we may reach an opposite conclusion.

Miller and Roth studied the hard palates of 1,040 patients ranging in age from birth to 64 years, of which 533 were males and 507 females. They grouped the subjects by 5-year spans and derived their statement from the combined results of both sexes in different age groups. These two points are subject to a different interpretation. As Miller and Roth had mentioned, the ratio of torus palatinus in male to female

TABLE 6
Distribution of torus palatinus by age and sex in the living
(rearranged from Miller and Roth, '40)

AGE	CASES		SLIGHT		MODERATE		MARKED	
	M	F	M	F	M	F	M	F
Birth to 9	78	82	8 10.26%	13 15.85%	1 1.28%	0	0	0
10-19	60	100	6 10.00%	22 22.00%	3 5.00%	6 6.00%	0	1 1.00%
20-29	77	83	11 14.29%	12 14.46%	1 1.30%	11 13.25%	0	3 3.64%
30-39	80	80	12 15.00%	19 23.75%	0	10 12.50%	2 2.50%	3 3.75%
40-49	89	71	12 13.48%	13 18.31%	4 4.49%	9 12.68%	0	6 8.45%
50-59	100	60	11 11.00%	10 16.67%	6 6.00%	9 15.00%	4 4.00%	8 13.33%
60-64	49	31	4 8.16%	6 19.35%	2 4.08%	2 6.45%	0	2 6.45%

is one to two. Though the present study does not indicate such a great sex difference (see next section), it is apparent that females have a higher percentage of the torus than have males. However, Miller and Roth combined the results of both sexes with unequal numbers of males and females in each age group. Furthermore, the specimens were divided into as many as 12 age groups, so that the number of cases in each age group is small. The results thus obtained lack

uniformity and thereby the general trend is obscure and possibly misinterpreted.

If the data of Miller and Roth are rearranged by changing the age classes from 5 to 10 years, and by computing the percentage instead of the number of cases of each type of the torus in each sex separately as shown in table 6, a different conclusion may be reached. It is not apparent from this rearrangement that the slight form of torus gradually decreases and the moderate and marked forms gradually increase with increase of age.

In conclusion, torus palatinus may be present prenatally and gradually increases in size from birth to maturity. At approximately 20 years of age it ceases to grow, in accord with other bony structures, and does not increase with age.

SEXUAL DIFFERENCES

The results of the present study are given in table 3. Females in all series have higher percentages of the torus than the corresponding males. However, the difference in no series is larger than 10%. It is interesting to note here that the sex difference of the torus on dry skulls is much less than that in the living as reported by Lachmann ('27) and Miller and Roth ('40). On the other hand, the percentage of the torus observed on dry skulls is much higher than that in the living. Miller and Roth ('40) reported only 26.67% of the torus in adult Americans. Though they did not mention the racial components of their subjects, yet judging from the fact that the data were drawn from the examination of persons applying for treatment at New York University Dental Clinic, they are probably, with possibly a few exceptions, American Whites and Negroes. Thus their series should be comparable to the American White and Negro series of the present study as shown in table 3. It may be seen that the studies of the torus in the living show its incidence to be only two-thirds as frequent as shown by studies of dry skulls. However, the sexual difference is much greater in the living than in dry skulls. This could probably

be accounted for by the following facts. Since the torus is covered with mucosa and its lateral borders somewhat obscured by vessels, nerves and particularly mucous glands, it seems logical that some of the smaller tori might be difficult to detect in the living. However, the small torus constitutes more than half of the total percentage. Thus the percentage of the torus observed in the living might be much less than that on dry skulls. Concerning the much greater sexual difference in the living, it may be pointed out that the higher percentage of the torus in the female is in general not evenly distributed among all three types but tends to shift to the medium and large types as shown in table 3. As mentioned above, certain small tori in the living may escape observation, whereas the larger ones certainly could not be missed, and thus the combined results would greatly exaggerate the sexual difference.

RACIAL DIFFERENCES

Torus palatinus has been found in different racial groups, such as Prussians (Kupffer, 1880 and Lissauer, 1885), Ainus (Kopernicki, 1882 and Tarenetzky, 1890), Lapps (Waldeyer, 1892), Icelanders (Hooton, '18), Prussians, Ainus, Eskimos, Peruvians, and Negroes and Hottentots (Stieda, 1891), and in Peruvians, Ainus, Eskimos, Lapps and Finns, Tasmanians, Australians, Fuegians, American Indians, Patagonians, Polynesians, Hindus, Melanesians, Malayans and Negroes and Hottentots (Godlee, '09). Different racial groups have different frequencies of the torus. Unfortunately, the results of groups of the same race reported by different authors differ greatly. For example, Stieda (1891) gave a high percentage of the torus in Peruvians (56.3%) and Ainus (60.0%) whereas Godlee found only a small proportion (8 in 97 Peruvian skulls or 8.25%, and 1 in 7 Ainu skulls or 14.29%). Stieda (1891) reported the percentage of the torus among Eskimos as 60.0%, American Indians as 40.05% and Peruvians as 56.3%; while Russell ('00) found 18.6% for Eskimos, 14.4% for American Indians and 0.2% for Peruvians. The

discordant results of different authors are possibly due to the small number of cases and to different standards. Some authors included certain small forms and others did not. However, both Stieda (1891) and Godlee ('09) agreed that the palatine torus occurs rarely among the Negroes and Hottentots. Martin ('28) found 18.9% among the South Africans. Godlee ('09) reported that the torus is very common among the Tasmanians and Australians and Martin ('28) reported 72.0% among Australians.

The results of the different series of the present study are given in table 3. It is seen that the Eskimos have the highest percentage of torus palatinus, the American Indians the next, then the Mongolians and the American Whites, and lastly the American Negroes. The incidence in the Eskimo series is intermediate between that of Hooton (76.7%) and of Stieda (60.0%). The range of the torus among Europeans given by Martin ('28) is from 13.8% (Bavarians) to 52.0% (Italians). In the present study 43.33% of American Whites have this character.

It may thus be concluded that in general the Australians or related groups have the highest percentage of the torus, the Mongolians or related groups next, then the Whites, and the Negroids the least.

Van den Broek ('45) studied the palates (from plaster casts) of the skulls of Le Moustier, Steinheim, Elmenteita, Fishhoek, Talgai, Gibraltar, Wadjak I, Oberkassel, Cro-Magnon and Brünn, and found that only the Cro-Magnon skull possesses a small palatal ridge. Weidenreich ('36) could not study the palate of the *Sinanthropus pekinensis*, but Adam ('43) reported the occurrence of torus palatinus in the Keilor skull.

OCCURRENCE IN SUBHUMAN PRIMATES

Godlee ('09) and Martin ('28) reported that torus palatinus does not occur among anthropoids. Weidenreich ('36), however, stated that it "is not uncommon in *Macacus rhesus*." But van den Broek ('45) was unable to confirm Weidenreich's

opinion. He reported that he did not find any case of the torus in mammals besides man, not even in a great number of primates. The present author examined the palates of 186 anthropoid apes and of 50 macaques and found no case with the torus. However, in a personal communication of April 28, 1948, Professor A. H. Schultz of Johns Hopkins

TABLE 7

Different types of torus palatinus and palatal index (P.I.) in American White and Negro series

SERIES	SEX	CASES	LARGE		MEDIUM		SMALL		NONE	
			no.	P.I.	no.	P.I.	no.	P.I.	no.	P.I.
American	M	534	15	77.50	69	83.54	145	84.64	305	83.11
White	F	126	4	80.08	21	82.21	31	86.18	70	86.57
American	M	572	12	74.24	67	76.62	127	77.53	366	77.43
Negro	F	299	18	79.01	43	78.43	61	79.62	177	78.36

Medical School kindly informed me that he found the character in a chimpanzee skull (fig. 12) with the following statement:

"It is an adult male chimpanzee in my collection (no. A.S. 1695). The skeleton of this ape is perfectly normal, slightly more than average in size, all epiphyses are closed and the dentition is complete and somewhat worn. The torus is small, as compared to many seen in man, but it is there."

From this, it may be seen that the occurrence of torus palatinus even in anthropoid apes is exceedingly rare.

RELATION OF ITS SIZE TO THAT OF HARD PALATE

Martin ('28) suggested that the broad torus is mostly found in meso-orthostaphyline and the small torus in leptohypsistaphyline. Palatal indices of the present American White and Negro series were computed and classified according to size of the palatine torus in table 7. These data do not support Martin's opinion. It is interesting to note that in both series the large type of torus has the smallest

palatal index and the small type the largest one, with the palatal index of the medium type intermediate. It seems to indicate that when the torus is present, its size has a definite relation to the size of the palate, i.e., the narrower palate has a larger torus and the broader palate has a smaller torus. However, the palatal indices of those skulls without torus are not the largest but intermediate between those of the small and medium types, or near the mean value of the total population.

TABLE 8

Percentages of tori maxillaris and mandibularis in those skulls with and without torus palatinus in American White and Negro series

SERIES	SEX	CASES (T. pal.)	T. max.			T. mand.		
			%	P.E. of difference	Difference ÷ P.E. ¹	%	P.E. of difference	Difference ÷ P.E. ¹
American White	M	229 (with)	6.99			8.30		
				.92	4.08		1.11	1.69
		311 (without)	3.22			6.43		
	F	56 (with)	3.57			3.57		
				1.34	1.60		1.52	.47
American Negro	M	70 (without)	1.43			2.86		
		208 (with)	19.71			17.79		
	F			1.69	1.69		1.57	2.68
		368 (without)	16.85			13.59		
	F	121 (with)	19.01			14.88		
				2.10	3.94		2.00	1.79
		177 (without)	10.73			11.30		

¹ The significance of the difference is estimated from the probable error as follows: Difference/P.E. greater than 4. — significant; 3.-4. — probably significant; less than 3. — not significant.

RELATION TO TORI MAXILLARIS AND MANDIBULARIS

Torus maxillaris is an occasional hyperostotic formation on the alveolar portion of the maxilla. It is usually located in the molar region on the lingual side of the dental arch in the form of little uneven tuberosities or a tuberosus welt (fig. 13). In rare cases the bony overgrowth may extend to the second premolar, or very exceptionally as far as the canine.

Torus mandibularis is a hyperostotic formation on the lingual surface of the mandible between the alveolar border and the mylohyoid line (fig. 15). These hyperostoses usually extend antero-posteriorly from the first premolar to the second molar, but occasionally they may reach to the lateral incisor and the third molar in the form of tuberos dull protrusions.

Percentages of tori maxillaris and mandibularis on those skulls with and without torus palatinus in the American White and Negro series are given in table 8. It is seen in both series that percentages of both tori maxillaris and mandibularis are higher in those skulls with torus palatinus than in those without it. It seems to indicate that a certain correlation exists among these structures.

Both tori maxillaris and mandibularis have not so far been reported in other primates than man. However, there is a case of lingual maxillary torus on the left side of a gorilla skull in the Washington University collection (fig. 14). It occurs as a bony tubercle just opposite the left third molar.

CAUSATION

The most popular theory on the causation of torus palatinus has been suggested by Hooton ('18). He considers the condition to be a form of hyperostosis which is the result of environmental adaptation, dependent upon the excessive development of the masticatory mechanism, a factor which produces pressure toward the median palatine region. The thickening of the palatine vault on each side of the median palatine suture acts, according to Hooton, as a buttress to resist the pressure. However, the greatest stress in mastication generally falls on the molar teeth and not on the middle part of the hard palate. Furthermore, as shown in figure 10, the direction of the pressure lamellae of the palatine torus is from anterior to posterior instead of from lateral to medial of the palate. It is generally considered that the configuration of the internal structure of a bone is correlated with the direction of mechanical and muscular forces acting

upon it (Koch, '17, '49; Townsley, '48). If the palatine torus is due to the vertical force of mastication, its system of pressure lamellae might be expected to run in the direction from lateral to medial instead of from anterior to posterior. Thus the pressure theory does not seem to be in accord with the structure of torus palatinus.

Recently, van den Broek ('45) claimed that the cause of torus palatinus must be sought in irritation (chemical or otherwise) of the mucous membrane. He contends that food and saliva during a relatively long time in contact with the mucosa can irritate the mucous membrane and, through these, the surface of the bone, and thus cause the formation of the torus. However, judging from the results of the present study, the palatine torus does not seem to increase in size with increase in age after maturity. Moreover, the percentages in all age groups after 20 years of age are nearly equal. This seems to indicate that if the torus does not exist at maturity, it will not be present at all. In other words, torus palatinus seems to be a hereditary character; its presence or absence is determined by hereditary constituents. In addition to the racial incidence of the palatine torus there is some evidence from the literature that it is familial. Carabelli (1842) reported that the character occurs in many families, affecting most of the members, although not all. Körner ('24) reported the occurrence of the condition in 5 families. Dorrance ('29) saw the torus in three generations of the same family. It seems justifiable to regard the torus as a genetic character. The occurrence of the torus may be considered to be the result of continued activity of embryonic osteoblasts of the hard palate which, when the dental arch is contracted and especially when the arch is narrow, piles up an excess bony tissue along the median palatine suture after the junction is completed. Since the torus occurs in all modern races as well as in the fossil, but is extremely rare in other primates than man, it may be considered as a specifically hominid character.

SUMMARY

Hard palates of 2,348 skulls of 6 series and skulls of 186 anthropoid apes and 50 macaques were examined for torus palatinus.

It is believed to be a normal anatomical variation and has no connection with any pathological condition.

The torus varies considerably in form and size. It is usually spindle-shaped or in a mound form. Sometimes it is narrow and highly arched. In rare cases, it may consist of masses of irregular shape. The small size is in general the most frequent and the large size, the least.

The torus is composed of a layer of compact bone on oral and nasal surfaces with intervening spongy bone.

It may exist in the fetal stage; it gradually increases in size from birth to maturity and then ceases to grow with age.

Females have a higher percentage of the torus than do males, but in no series is the difference larger than 10%.

Eskimos, American Indians and Mongolians have greater percentages of the torus than either American Whites or American Negroes. The Eskimo series has the greatest percentage and the American Negro series the least.

A case of the torus in a chimpanzee is reported.

When the torus is present in narrow palates it is usually the larger form, whereas in broader palates the smaller size occurs.

Skulls with torus palatinus have higher percentages of torus maxillaris and torus mandibularis than have those without it.

Torus palatinus seems to be a specifically hominid character, determined by hereditary constitution.

ACKNOWLEDGMENT

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PLATES

PLATE 1

EXPLANATION OF FIGURES

- 1 A case of exostosis with very pronounced torus palatinus in an American Negro female, age 57.
- 2 A torus situated on the middle part of the hard palate of an American Negro female, age 102.
- 3 A torus restricted to the posterior part of the hard palate of an American Negro female, age 60.
- 4 A torus restricted to the anterior part of the hard palate of an American Negro male, age 29.
- 5 Two elevations of a torus separated by a deep median groove in an American White female, age 68.

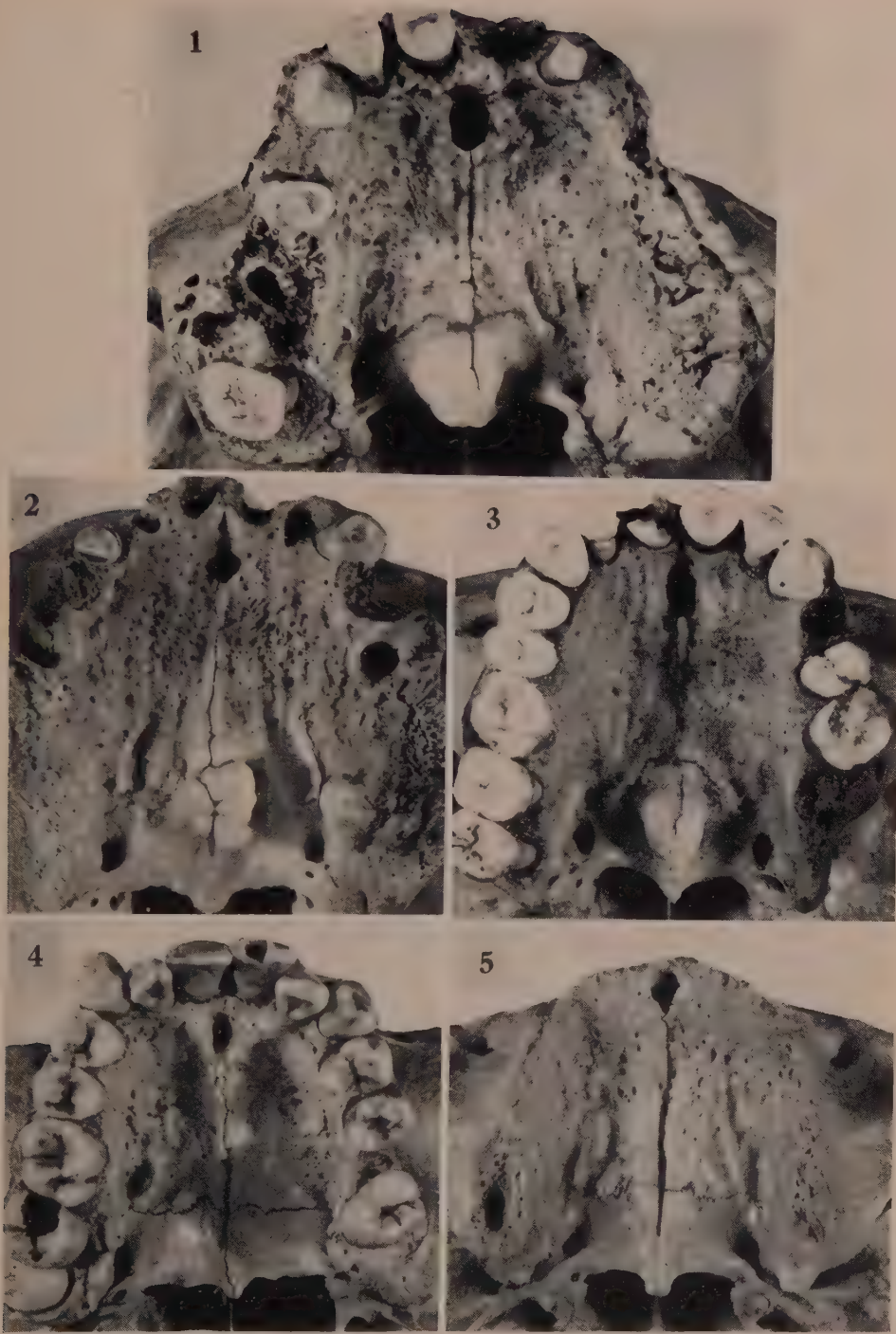


PLATE 2

EXPLANATION OF FIGURES

- 6 Ridge form of torus palatinus.
- 7 Mound form of torus palatinus.
- 8 Lump form of torus palatinus.
- 9 Frontal section through the palatine torus showing a layer of compact bone on oral and nasal surfaces with intervening spongy bone.
- 10 Microscopic view of a cross section through the middle of a palatine torus. Note the antero-posterior direction of the pressure lamellae. $\times 85$.

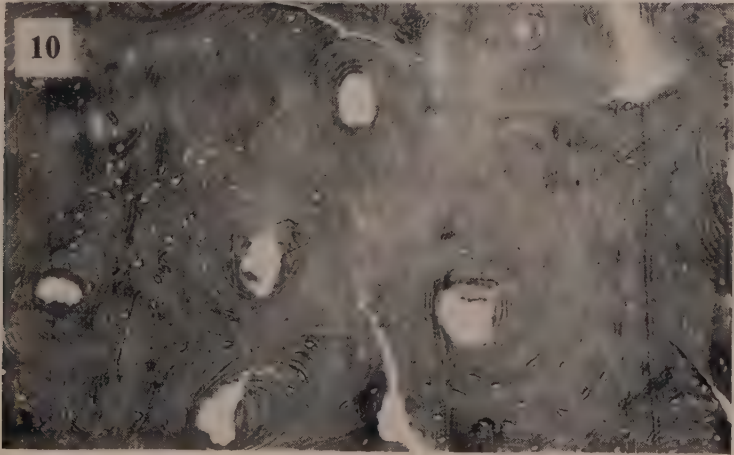
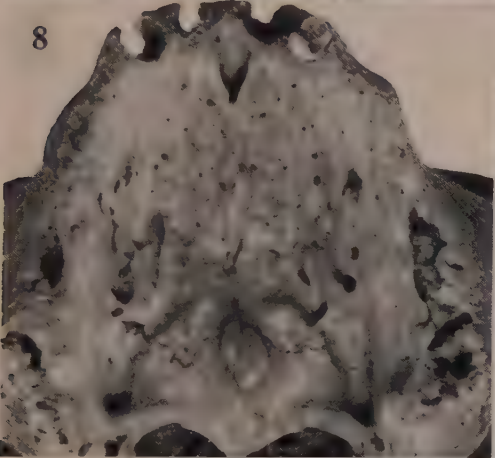
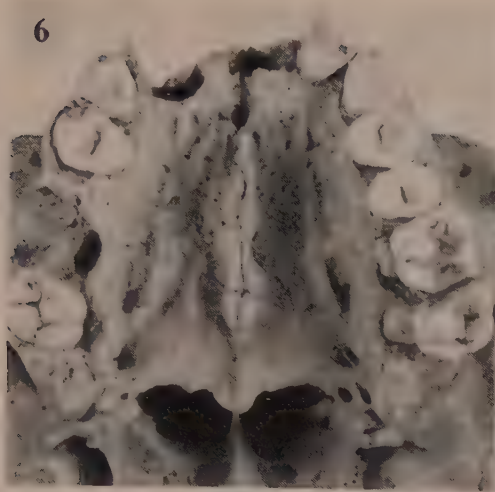


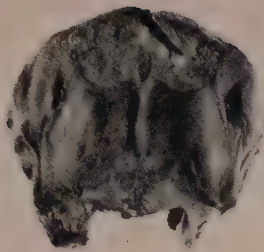
PLATE 3

EXPLANATION OF FIGURES

11 Hard palate of a fetus of approximately 34 weeks, showing an indication of the presence of torus palatinus.

12 Hard palate of an adult male chimpanzee showing the presence of torus palatinus (courtesy of Dr. A. H. Schultz).

11



12



PLATE 4

EXPLANATION OF FIGURES

13 Hard palate of an adult American Negro showing the presence of torus maxillaris.

14 Hard palate of a gorilla showing the presence of torus maxillaris opposite the left third molar tooth.

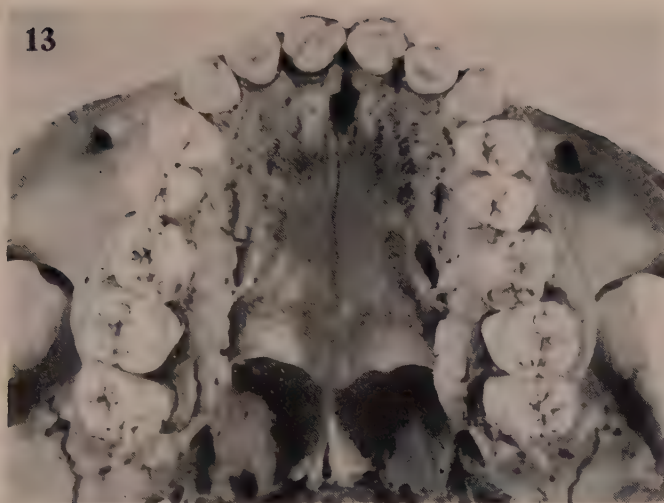


PLATE 5

EXPLANATION OF FIGURES

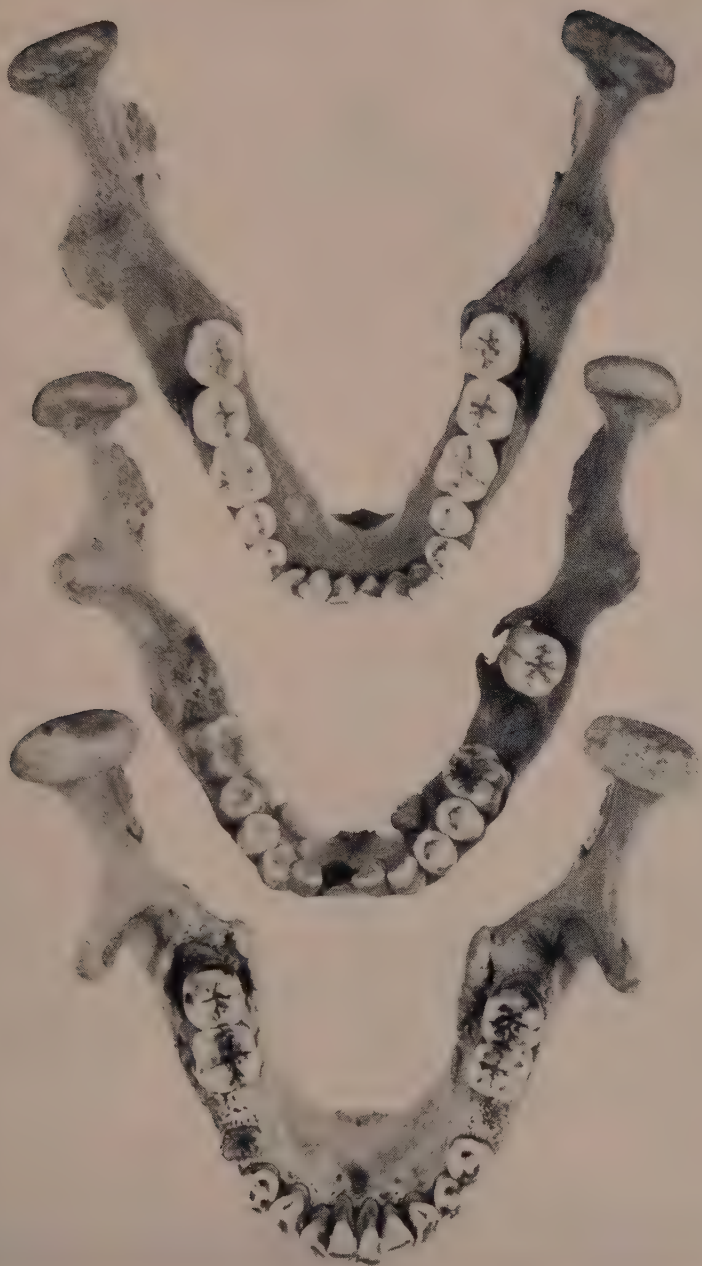
15 Mandibles showing the difference in form and location of mandibular tori.

Upper figure shows tori in the form of even protrusions at the anterior part of the lingual side of the mandible.

Middle figure shows tori in the form of tuberos protrusions at the anterior part of the lingual side of the mandible.

Lower figure shows tori in the form of even protrusions at the posterior part of the lingual side of the mandible.

15





THE WORK OF THE AMEGHINOS.—The partnership of the Ameghino brothers was an outstanding example of teamwork, and their achievement was one of the most remarkable in scientific history. When they began their career, one was an obscure provincial school teacher without formal scientific training or higher education and the other was his almost unlettered younger brother. Between them, the older brother in the study and the younger in the field, they revolutionized South American geology and rewrote one of the most important chapters in the history of the earth . . .

As a research worker, Florentino Ameghino was enormously productive. He was as articulate as Carlos was inarticulate. He was not yet 57 when he died, but he wrote nearly 200 memoirs and monographs, some of them of great length. His collected works fill 18 very bulky tomes, and his correspondence fills 4 more. His earliest work, 1875–1882, and his latest, 1907–1911, were mainly devoted to studies of fossil man, artifacts, stratigraphy as related to human antiquity, and related anthropological subjects. This work, mostly bearing on his claims that man arose in the Tertiary in Argentina, has been most extensively noticed and seems to be the main basis for his popular reputation in South America. It is, however, already fairly clear that his permanent place in the history of science will be due not so much to this anthropological work as to his less sensational studies carried out in the middle quarter century of his career, 1883–1906, when almost all his efforts were devoted to the non-human fossil vertebrates of Argentina, especially the mammals.—George Gaylord Simpson. The beginning of the age of mammals in South America. Pt. 1. *Bull. Am. Mus. Nat. Hist. N. Y.*, vol. 91, art. 1, 1948, 232 pp. and 19 pls.

FRANCIS EUGENE RANDALL, 1914-1949

ROBERT M. WHITE

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With the death of Francis E. Randall the field of applied physical anthropology suffered a great loss and a promising career was cut short. He was killed in the crash of an airliner at Washington on November 1, 1949, while en route to The Quartermaster Board at Camp Lee, Virginia in connection with his work in Army anthropology.

The son of Mr. and Mrs. George F. Randall, Frank Randall was born on April 1, 1914, in New Philadelphia, Ohio and attended the public schools there. In 1932 he entered Western Reserve University in Cleveland, where he majored in zoology and received an A.B. degree in 1936. There followed two years of graduate work at Western Reserve, with an M.A. degree in 1938. During this period, he was a research fellow in biology at the Cleveland Clinic and was also associated with the Brush Foundation in the study of growth and development in children. During the next two years, Randall held the position of teaching fellow in physical anthropology at Western Reserve, working under Todd and instructing in anatomy in the School of Medicine. In 1940, Randall went to Harvard to work under Hooton, and took courses in both biology and physical anthropology. His Ph.D. in 1942 was a split degree between the two departments and was the result of his work on the skeletal and dental development and variability of the gorilla, which was later published in *Human Biology*.

Early in 1942, Randall went to Wright Field, Dayton, Ohio, on a Civil Service appointment as a research physiologist for the Army Air Forces. He was commissioned in July,

becoming head of the Anthropology Unit at the Aero-Medical Laboratory. The program there involved extensive research work in physical size studies on aviation personnel for the purposes of coordination with the design of aircraft and related flying equipment. It also involved development of several types of flying equipment, such as flight clothing, helmets, and oxygen masks. Randall was instrumental in developing an oronasal mask on which he held a patent. In recognition of his work in the Air Forces, Randall received the Legion of Merit. In 1946 he was separated from the Army with the rank of Captain, and reverted to an inactive status but retained his commission as a Major, ORC.

In March, 1946, Randall began his association with the Quartermaster Corps when he became a consultant in the Research and Development Branch, Military Planning Division, Office of the Quartermaster General in Washington. In the ensuing months, he was largely responsible for the organization, planning and direction of the Quartermaster anthropometric survey. This included the procurement of anthropometric instruments, the planning and development of procedures and techniques, and the organization and training of military personnel who took the anthropometric measurements. A total of over 100,000 men and 9,000 women in the Army and Air Corps were measured by teams working at 6 separation centers, and a large series of standard somatotype photographs was obtained, which is now in the hands of Dr. Hooton at Harvard. In November, 1946, Randall received an appointment under Civil Service as an anthropologist and became head of the Anthropology Unit at the Quartermaster Climatic Research Laboratory in Lawrence, Mass. The work of this laboratory is an integral part of the program of research in human biology being carried on under the Environmental Protection Section, Research and Development Branch, Military Planning Division, Office of the Quartermaster General.

Due to his enthusiasm and effort, Randall built up the field of applied physical anthropology in the Army to a level

where it is assuming more and more importance. With the data of the anthropometric survey as a basic reference, studies of fit, size, size systems, and tariffs were developed, with the concept of correlating the body sizes of Army personnel with military clothing and other types of equipment used by them as the guiding principle. Randall's conception of this work was two-fold in that it could furnish necessary and useful data in physical anthropology as basic research and at the same time could be used in the applied sense in dealing with specific Army problems such as the improvement of clothing and other equipment. Randall was interested in various basic problems in physical anthropology, such as growth, age changes, and variation, to name but a few, and was constantly seeking new data relative to such topics in his Army material.

In the field of applied anthropometry, Randall's approach to the clothing problem was an outstanding contribution in which he was just beginning to achieve significant results. His work was a combination of anthropometry, statistics, and education. Education, in a larger sense, was necessary in convincing those with whom he was associated that he really had something to offer in his method. He used standard techniques in both anthropometry and statistics, but never hesitated in trying out or substituting experimental modifications when necessary, with the result that some of his ideas were unorthodox but extremely effective. In explaining and "selling" his methods of practical anthropometry and statistics, he faced the problem, inevitable in a comparatively new field, of doubt on the part of those with whom he had to deal. This was especially true in the clothing field.

In January, 1945, Randall was married to Edna G. Gilmore of Grand Rapids, Michigan. They lived at Canobie Lake, New Hampshire. Among many other interests, Frank became an enthusiastic devotee of sailing on the lake. Last year, Randall and his wife had begun a joint anthropometric study of Lawrence school children. In addition to his wife,

Randall is survived by his parents, and also a brother, Raymond, who reside in New Philadelphia, Ohio.

Much of Randall's writing was in the form of official reports on his work in the Air Forces and Army, which were usually classified and which had a limited distribution. However a number of his articles have been published in professional journals, and are listed in the accompany bibliography.

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REVIEWS

MAN AND HIS WORKS. By MELVILLE J. HERSKOVITS. Alfred A. Knopf, New York. xviii, 678, and xxxvii pp. 1948 (Text, \$5.00; Trade, \$6.50).

Introductory textbooks of anthropology are still few and far between, as compared with the spate of such works in other social sciences since 1946; none the less, today anthropology is more fruitful in this regard than ever before. But the course-work of anthropology is still so unstandardized that its content is bound to be shaped by the choice of text much more than is true of certain other fields: the author has wide liberty to roam among materials and principles — and to present the Thing As He Sees It.

So Dr. Herskovits introduces the college student to anthropology under the title, *Man And His Works*; the sub-title explaining that this is to mean *The Science of Cultural Anthropology*.

There are 38 chapters, blocked off into 8 sections: Introduction; The Nature of Culture; The Materials of Culture; The Structure of Culture; The Aspects of Culture; Cultural Dynamics; Cultural Variation; Summary. Within the block of the Materials of Culture, its first and third chapters (chs. 7 and 9 of the overall scheme) are concerned with man himself: The Evolution of Mankind, and Physical Type and Culture. The reviewer is not certain as to why these are called the Materials of Culture.

These two chapters are all that concern this review. By inserting them into a book of cultural anthropology, Herskovits is declaring that culture derives partly from the "biological component of human existence" (p. 628), and that the college student should know that fact.

Now, within the tribe of physical anthropologists, there certainly is a number (the writer among them) who are not happy over the fact that our geminate discipline of anthropology has never come to grips with the issue of exactly why or even whether we are Siamese. Bluntly — what need has cultural anthropology of physical? If the essentials of cultural anthropology need no props from the physical, why take up a student's precious one-year course at all with the few days or weeks of man's physical evolution and differentiation?

I ask the question because Herskovits' two chapters do not make this obvious, beyond the statement (p. 148) that culture has affected physical type far more than the reverse. But this criticism hits us all; not Dr. Herskovits particularly. If the student is to be introduced to man as well as his works (and at least as many students as not, enter their introductory class quite ignorant of what "anthropology" means; to say nothing of what it covers), what should be a minimum satisfactory ration?

The evolution of man, runs Dr. Herskovits' answer in chapter 7, is read out of the fossil finds, which present difficulties of interpretation and reconstruction. Another line of evidence is that of comparative anatomy, which places man as a Primate who changed structure enough to become an upright biped. There follows a descriptive list of fossil finds from eastern Asia and the Indies, to which Weidenreich's interpretation is attached. Dr. Herskovits concludes this segment of the discussion with the observation that "racial (sic) differentiation may have been a commonplace in human experience even as early as this" (p. 106). Most of the other important fossil finds are then listed and briefly described. Man is concluded to be a "full-fledged member of the biological series." As sample evidence of his further differentiation are cited his increase in brain volume, in facial angle, in U-shape of the palate, and in erectness of posture, over the anthropoid. But "the story of man's development affords but few materials for those who would correlate physical type and culture" (p. 113).

Chapter 8 sketches the cultural prehistory of Europe, and discusses briefly its analogue in the Western Hemisphere. Chapter 9 resumes the topic of man, in terms of his races. Again, the title of the chapter, as well as the sense of the book as a whole, shows that the intent is not that of presenting raciology *per se*, but to examine its relevance to culture.

"What is race?" asks the author. "Science answers the question this way: 'A race is a principal division of mankind, marked by physical characteristics which breed true.'" The two features of this sentence are handled sequentially. First, man is metrically variable (the fact is disciplined by some accompanying frequency curves); and "greater differences exist in the range of physical traits that characterize any single race of mankind, than between races taken in their entirety." There follows a tabulation of diagnostic anatomical traits which in combination mark off the three major races of mankind. Second, to "breed true" is treated in terms of interbreeding and inbreeding. Here Herskovits' main reliance is Boas' mathematical essay in familial and fraternal variation: *On the Variety of*

Lines of Descent Represented in a Population (American Anthropologist, XVIII [1916]: 1-9). Man's racial traits are now indicated as phenomena of domestication. Herskovits refutes racism, and includes therein a brief historical sketch of the origins of racist doctrines.

The chapter is a sane and readable treatment throughout. This reviewer admired particularly Herskovits' skill in wrestling with Boas' theoretical analysis, that he might tame it to the point where a tyro could ride it. And to account for an idea (here racism) via its historical development, is the way it should be done, but is done too seldom. To draft the American exponents of racism, instead of pointing at another and too easily spectacular an example, is good teaching principle. Indeed, Dr. Herskovits consistently writes a straightforward English; he applies his tools to the task of explaining a very involved situation in such a way that the student is able to plod forward, without having to join in a game of intellectual follow-the-leader such as some of the exponents of our discipline seem to prefer.

On the whole, *Man and His Works* is an admirable book. And yet — well aware that the critic has the easier time than the doer — we must register, over some of the features, less than enthusiasm.

In chapter 9, as in other parts of the book, the feeling persists that Dr. Herskovits is a little too hurried in passing to the DEF of the topic before the ABC has been made clear to the novice. To be sure, nothing so far perceived about the human phenomenon is un-fraught with perplexities and paradoxes; but in introductory science we cannot start with these, even for the sake of avoiding dogmatism and oversimplification. The scientist can so overimpress the layman with his honest doubts, that he confuses his hearer more than he convinces him. We who are in science know how to take each other's qualified convictions; the student does not.

Physical anthropologists, I am sure, would prefer to see an introductory text develop the story of man's evolution out of a Tertiary Primate stock, during the peculiar and exceptional period of the Quarternary, and his latter-day racial diversification as a continuity. One misses such a tie-up between the topic of chapter 7 and that of chapter 9. To continue first of all with the treatment of race, there is no account of racial geography, nor of ethnic migrations and the hybridization that this makes possible. And at this juncture I would be willing to trade the abstract of Boas' familial and fraternal variation for a grass-roots introduction to Mendelism: something which we cannot assume to be part of the intellectual baggage of the arriving Freshman. To include the former idea but to omit the latter, is not a balanced diet. Sex dimorphism, constitutional morphology,

blood-type frequency, all cut across racial morphology, yet without obscuring it; and no modern discussion can afford to omit them. This reviewer has already given three cheers for Herskovits' approach to racism via the historical route; but race, too, is an idea with a history. Does not the main and scientific concept deserve at least as well as its aberrant spawn?¹ And—in an introduction to anthropology (that discipline which pretends to some kind of role as a master-synthesist of the science of man), is there no place for a treatment of the biodynamics of modern man?

But these criticisms apply only if we believe that physical anthropology has more than ancillary and gratuitous meaning in the introductory college survey. It is culture on which Herskovits strings his beads. In so far as he sees the problem of race as germane to the problem of culture, he has a place for it; his book does not intend to expound race in its own right. But if we insist that the elementary student deserves better at our hands in the story of his own origin and that of his kind, then much remains to be said. What the physical anthropologist challenges is the fact that the body of American anthropologists have failed to resolve the issue in their own house, just at a time when they are bidding to make their discipline that celebrated arch-synthesist. The core concept of anthropology as social science is culture; the core concept of anthropology as biological science is continued human evolution. Is an introductory course in anthropology properly the one, or the other, or both? Is one of these ideas more important than the other? Are they at all related? If so, how and in how far? Is it not true that the comparative status of their current presentation in curricula reflects external and mechanical conditions rather than their intrinsic significance? Is there any remedy?

There are some special things to say about chapter 7, that on the Evolution of Mankind. It is a less felicitous chapter than the 9th. Some of its mistakes are trivial, but they are repeated very often indeed. The canons of binomial nomenclature simply are not followed: *homo sapiens*, *pithecanthropus Erectus*, *sinanthropus Pekinensis*, *homo*

¹The following titles are not offered by way of comparison with Herskovits, but rather to elucidate on the positive side what can be said about race in non-technical language; and what is said in them is indispensable to the layman: W. W. Howells: *The Physical Determination of Race*. In: *Contemporary Social Theory* (H. E. Barnes et al., eds.): pp. 264–278. New York 1940; C. C. Seltzer: *The Jew—His Racial Status*. Harvard Medical Alumni Bulletin, April 1939, pp. 1–11; H. P. Fairchild: *The Truth About Race*. Harper's Magazine, October 1944, pp. 418–425; S. L. Washburn: *Thinking About Race*. Science Education, Vol. XXVIII, 1944, pp. 65–76.

neanderthalensis, or *Neanderthalensis*, *eoanthropus* — all contending with their correct forms, with no visible regularity. The brain volume for Anthropoids is given thus: Minimum-Maximum 300–385; Average 415 (p. 112). There is no explanation of the terms paleo-anthropic, neoanthropic, though they are used repeatedly; proto-anthropic is not used. Then, on p. 109, apropos of possible hybridization between Cro-Magnon and Neanderthal man, we read: "The best opinion now holds that crossing between neoanthropic man and *homo sapiens* (sic) was not only possible, but probably occurred to a considerable degree. This hypothesis is borne out by the fact that in museum and laboratory skull collections, specimens of present-day individuals appear with distinct neoanthropic traits — traits that have unwittingly been carried by persons whose physical characteristics while living were not measurably distinct from the others among whom they lived." The author simply does not know the meaning of neoanthropic; yet, on his preceding page, he quotes McGregor, who of course uses the terms paleoanthropic and neoanthropic correctly. As for this evaluation of Neanderthal man — the reviewer has no objection; others would place a marginal *caveat*. What is the proper fare for Freshman?

It seems to me, further, that to talk about the Pleistocene and Pliocene without any explanation of them (let alone placing them in their larger geological frame) is again confronting the tyro with the DEF without the ABC. And it helps not at all to have the Quaternary "epoch" (sic) drawn in, without any effort to correlate terms. (There certainly is no effort made to correlate the geological scale with the archaeological, in the succeeding chapter.) What will the Freshman do with this at examination time?

Nor is the implication (p. 102) that the anthropoid ape grasps and fights with his teeth, as contrasted with man, a particularly happy point; still less happy is the notion that the anthropoid skull is thicker than the human. On the same page appears a simple line figure to show the basic skeletal orientation of quadruped (dog?), ape, and man. For bipedal and erect gradation, there has been, of course, no more crucial remodeling than that of the pelvis. This is completely misdrawn, especially in the case of the ape. Another crucial feature — the human longitudinal pedal arch — is not shown at all: Herskovits' human is a frank flatfoot. Yet better design would have been but a mere matter of a pen-stroke. (The dog is better.) The range of brain volume in Neanderthal man is given as 1220–1610, with an average of 1400; that of modern man, as 1225–1540, with an average of 1300. Herskovits' conclusion is that average Neanderthal man had a larger brain volume than average modern man. The figures are taken from,

and credited to, Weidenreich. In a book of this scope, naturally we cannot expect the author to develop the discussion. But brain volumes are notoriously tricky data. The maximum for both modern males and females is far above the figure borrowed from Weidenreich, as is well known. Wherever Weidenreich may have gotten his average of 1300 for modern man, at least 1300 is the average for European *females* as given by Martin (p. 746). Neanderthal man's brain was quite respectably comparable in size to that of neoanthropic man; but we need not overdo it. Moreover, Weidenreich's belief in a monster gigantopithecine ancestor for *Homo sapiens* is hardly coin of the realm; yet no alternative is offered our trusting Freshman.

But enough of this. These criticisms focus on the 2 chapters out of 38 which have the least immediate bearing upon what Herskovits is trying to do. Undoubtedly, when he rewrites them he will improve them greatly. Meanwhile, the undying issue which they arouse comes back to perch on our doorstep. Anthropology has already contributed not one but two great and fundamental concepts to modern thought. How relevant each is to basic education, is still to be thought out to the end. An increasingly culture-conscious society has begun to give cultural anthropology its due—and to hurl an ever weightier challenge to it. But cultural anthropology with a perfunctory wedge of physical inserted is not balanced anthropology—it is hardly Man as well as His Works. And some day this society (or its filiate, perhaps?) may well wish that it had begun sooner to take the other contribution seriously. To go no further—all anthropologists will wish that we had explored together the high and low places of social biology, and had delivered our results to the lay thinking portion of our society.

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THE VERTEBRATE BODY. By ALFRED SHERWOOD ROMER. W. B. Saunders Co., Phila. and London, viii + 643 pp., 363 figs. 1949 (\$6.00).

The Vertebrate Body represents an application of the functional historical methodology to a biological problem. For that reason alone, it is an exceedingly important contribution. Although few of the data are new, the synthesis of all relevant material plus the constant application of principles of function and the historical depth of paleontology makes *The Vertebrate Body* a new and significant departure.

The Vertebrate Body "is designed to give in brief form, a history of the vertebrate body . . . Knowledge of vertebrate structure is of practical value to workers in many fields of animal biology. To the future medical student such a study gives a broader understanding of the nature of one specific animal type on which his later studies will be concentrated" (p. 1). Thus, *Homo sapiens* as a subject for study has been omitted intentionally. Moreover, in the entire work only half a paragraph is devoted to the order Primates — when they are discussed along with the various mammalian orders. *Homo sapiens* receives only incidental mention — as in equating the anatomical terminology of human and lower forms. Although I heartily agree with Dr. Romer's approach, I believe from my biased viewpoint that the order Primates has been slighted too much. As a whole, however, the value of *The Vertebrate Body* to the introductory physical anthropology student, like the future medical student, lies primarily in helping him to view man and the other primates as variations on the vertebrate pattern.

The plan of the work runs: *Introduction, the Vertebrate Pedigree, Who's Who Among the Vertebrates, Cells, The Early Development of Vertebrates*, ten chapters devoted to the various organs and organ systems, and lastly three good appendices — *A Synoptic Classification of Vertebrates, Scientific Terminology and References*.

The style is lucid with little or no chance for confusion. As an instructor in elementary physical anthropology, I cannot help but throw bouquets to Dr. Romer for anticipating student pitfalls. The *Introduction* is particularly exemplary, for such concepts as "The Vertebrate Body Plan," "Directions and Planes," "The Homology Concept," "Adaptations and Evolution," "Surface-Volume Relation" and "Nomenclature" are discussed. Moreover, under the topic of nomenclature the student is referred to Appendix II which includes a section of Latin noun declensions. This chapter alone represents a tremendous saving of time to instructors of elementary anthropology. Throughout the book, this type of anticipation occurs, for example:

"In comparative anatomy we compare the organs of *existing* members of different groups as if one had descended from the other; as if mammals had descended from the existing reptiles, these from existing amphibians and fishes" (p. 30).

(vermiform appendix) "This is frequently cited as a vestigial organ supposedly proving something or other about evolution. This is not the case: a terminal appendix is a fairly common feature in the cecum of mammals, and is present in a host of primates and a number of rodents" (p. 363).

The presentation throughout is clear and direct. As new concepts or new terms arise, they are defined concisely and all ambiguities clarified. For example: "A tract is generally given a compound name, the two parts of which designate its origin and termination; thus the corticospinal tract carries impulses from the cortex of the cerebral hemispheres to the motor cells of the spinal cord" (p. 565). Furthermore, attention is constantly focused on wholes and relationships, a few examples of which will be illustrative:

"Cytology, histology, and cellular physiology are special fields of study and research which deal with cells and tissues. Here we shall but briefly review our knowledge of these topics as a background for a better understanding of structures of greater complexity with which the remainder of the work is mainly concerned" (p. 65).

"Most of the major events in vertebrate embryology are well known, but the mechanisms of development are in most regards still a mystery, and the solution of the chemical and physical problems involved is the chief concern of modern embryology" (p. 110).

"The comparative study of musculature is a difficult procedure because of the variability of muscles and the apparent ease with which their functions may alter" (p. 253).

"It must be remembered that much of hormone study has grown out of medical work, and is confined in great measure to man and a few laboratory animals. In consequence there are, without doubt, many hormones and hormone functions in lower vertebrates of which we have as yet no knowledge" (p. 424).

Of the sections on the organs and organ systems, the most detailed exposition has been given the skeletal system. Here, because of the wealth of paleontological data, Dr. Romer has been able to demonstrate to the full his methodology — which I have likened to the functional historical. Structure is related to function and to embryological history, and hypotheses based on the present time plane are subjected to the final check of history in the form of the fossil record. Because of this significant approach, the student is able with very little effort to grasp the vertebrate skeletal plan as a whole.

The Vertebrate Body is a welcome addition to the library of physical anthropologists for its invaluable help to beginning students and as an excellent example of craftsmanship in synthesizing and organizing data from so many disparate fields.

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HISTORY OF THE PRIMATES. AN INTRODUCTION TO THE STUDY OF FOSSIL MAN. By W. E. LE GROS CLARK. British Museum (Natural History), London. 117 pp. 1949 (2 s. 6 d.).

This little book has been prepared by Professor Le Gros Clark as a guide for use in connection with viewing the remains of fossil man in the British Museum of Natural History. However, it is in no sense a guide book to specific collections. It is a brief and wholly admirable treatment of the entire subject of Primate evolution and the emergence of man as shown by fossil evidence. The author manages to write simply and clearly without being dogmatic or arbitrary. This reviewer considers the result of Professor Clark's efforts as the best and most up-to-date condensed summary of Primate evolution he has been privileged to read. It should be used widely in introductory courses in Anthropology as well as in courses on Palaeontology and Zoology.

Some of Professor Clark's views which particularly interest this reviewer are:

- (a) His inclusion of the tree-shrews among the Primates.
- (b) His suggestion that the anthropoid apes developed from fossil tarsoids without passing through a monkey stage.
- (c) His judicial reserve upon the dryopithecine question of the ancestry of man which recent discoveries in Kenya have raised anew.
- (d) His equally cautious position in regard to the notorious Pilt-down man.

No one can go wrong in studying this book and accepting most of its conclusions, because Professor Le Gros Clark is so careful not to go beyond the evidence. He does not "stick out his neck." A "guide book" ought to direct the reader along the middle of the safest road and this book does that. I approve it; I admire it; my students will have to read it; I recommend it to all anthropologists and to sundry intelligent laymen (including sociologists who give courses on anthropology).

EARNEST A. HOOTON
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THE ANATOMY OF SEMNOPITHECUS ENTELLUS. By Ananthanarayana A. Ayer. The Indian Publishing House Ltd., Madras, 182 pp., 99 figs. 1948 (201 rupees).

This monograph is a welcome addition to the literature on the Primates, especially since it deals with one of the more neglected as-

pects of primatology, the anatomy of the Old World monkeys. There is little doubt that considerably more is known about the morphology (and especially the all-important aspect of variability) of the anthropoid apes than about that of the catarrhine monkeys. This is due in part to the fact that whereas there are at best only 5 genera of living anthropoids there are at least 11 valid genera of Old World monkeys, in part to the unavailability to students of certain monkey genera, but largely to a dominant interest in the anthropoid apes because of their supposed closer relationship to man. The catarrhine monkeys, moreover, exhibit a superficial group uniformity and apparent lack of variability that can be both disarming and misleading. One need only consider Washburn's ('42) study of langurs to see how diverse some related groups can be in certain characters and how some forms can have a normal range of variation that exhibits features commonly thought peculiar to the so-called higher primates.

A considerable amount of information respecting the anatomy of the catarrhine monkeys is scattered throughout the literature, largely in studies dealing with particular organs or regions of primates in general. But comprehensive studies of a single genus or even of a single species are conspicuous by their absence. For the subfamily Cercopithecinae we have only "The Anatomy of the Rhesus Monkey (*Macaca mulatta*)" ('33), a collective effort of 18 authors. For the subfamily Semnopithecinae there was hitherto only the excellent but less ambitious and incomplete study of the guereza, *Colobus*, by Polak ('08). In neither of these works is there any real attempt to deal with the problem of variability—a problem that is especially difficult to deal with respecting the soft parts. Rather, these works serve as the necessary first steps or bases for future, more extensive special studies of the particular animals.

Ayer's monograph on another member of the Semnopithecinae, the langur *Semnopithecus entellus*, is a basic study of the same sort. It exhibits both the strength and the weakness of single authorship. Thus it has unity of presentation; but it contains gaps and superficialities. Based upon the study of three embalmed animals and two skeletons, it covers most of the more important aspects of the animal: external characters, dermatoglyphics, skeleton, articulations, musculature, dentition, digestive system, respiratory system, urogenital system, endocrine glands, vascular system, central and peripheral nervous systems, and eye and ear. The general quality of description is high, but the chapters are of unequal value. Among the best sections, in the opinion of the reviewer, are those that

deal with the musculature of trunk and limbs, the stomach, and the liver. But when reading the first of these, the reviewer cannot but wonder why "the human normal condition" (whatever that may be) rather than either *Colobus* or *Macaca* was chosen as the standard for comparison; and it is a bit dismaying to encounter such descriptive terms as "similar to those of man" and "as in man," which most comparative anatomists have long since discarded as being without real meaning.

The illustrations are of uneven quality. The line drawings are for the most part clear and useful, but the photographs had better been omitted.

This work was completed in 1942, which explains why references to later publications are not included in the list of literature. Yet nearly all of those given are in the English language. Furthermore, many earlier important and pertinent works are not considered. This is undoubtedly due largely to the difficulties of securing certain publications in Madras, but, unfortunately, it reflects itself throughout, and particularly in the author's conclusions, which appear at times to be overenthusiastic. Thus it is doubtful if present knowledge permits one to conclude that "*Semnopithecus* holds a unique place among the living Old-World monkeys" to the extent that its affinity to "the hypothetical precursors of the Catarrhines . . . appears to be more than that shown by any other Old-World monkey."

It must be emphasized, however, that defects such as those noted above appear to be almost inevitable to such an ambitious undertaking. The reviewer knows full well, for he was a party to a similar effort. With this in mind, he has no hesitation in stating that in his opinion Ayer has produced a thoroughly competent and extremely useful work, one to which every student of primatology should have access. But most important of all, perhaps, it may be regarded as a token of the high quality of primate research that is to be expected from India.

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THE EPITOME OF ANDREAS VESALIUS, translated from the Latin with preface and introduction by L. R. LIND with anatomical notes by C. W. A. ASLING, and a foreword by LOGAN CLENDENING. Macmillan Co., New York, 131 pp., 12 figs. 1949 (\$7.50).

Vesalius, the great dissector who almost singlehandedly created modern anatomy, was a realist. Together with his monumental folio,

the *Fabrica*, he brought out in 1543 a short compendium, the *Epitome*. While the former is praised now in all textbooks, it cannot have been read too extensively, to judge from the relatively great number of copies surviving in fine condition. The *Epitome* was read. Only twenty copies have survived.

The same external conditions that made for the greater consumption of the *Epitome* also favored its translation prior to that of the *Fabrica*. The effort was worthwhile. The *Epitome* is, beyond its historical interest, still a quite readable text on anatomy. The annotator points out rightly, for instance, that in its functional presentation of muscles it is more modern than the textbooks of the past century. In the two books on Bones and Cartilages, and Muscles and Ligaments, we can but admire the unprecedented precision and extension of Vesalius' knowledge. In the remaining four books on Abdominal Viscera, Thoracic Viscera and Vessels, Brain and Nerves, and Organs of Reproduction, Vesalius' knowledge is no less impressive; but as he was still depending on Galen's physiology, especially of "circulation," we see him misunderstand and misinterpret quite a number of correct observations. This seems another illustration of Daremberg's old dictum that the decisive element in a given period of medicine is her physiology.

Dr. Lind's very able translation and Dr. Asling's no less excellent annotations are followed by a photographic reprint of the 28 pages of the Latin original with its beautiful 12 woodcuts.

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VARIETIES OF DELINQUENT YOUTH. AN INTRODUCTION TO CONSTITUTIONAL PSYCHIATRY. By WILLIAM H. SHELDON with the collaboration of E. M. Hartl and E. McDermott. Harper and Brothers, New York, xvii + 899 pp., 1949 (\$8.00).

In this volume, third in the Constitutional Psychology series, Dr. Sheldon presents a detailed study of 200 young male delinquents followed over a period of years at the Hayden Goodwill Inn at Boston. In addition to the study itself, the book introduces a new system of psychiatric classification, new data on disease-physique relationships, and the hypothesis that delinquency is both a biological and a social problem that can be solved only by a society realistically concerned with its future.

The 200 cases are presented as a series of individual case histories, each taking about three pages: each includes a somatotype photograph, abridged medical, social and psychiatric histories, a brief statement of family background, and the author's comments. The cases, which occupy 605 pages of this large volume, are arranged in terms of a rough etiological diagnosis — "the predominant difficulty" as seen by Sheldon. The groupings include those boys characterized by "mental insufficiency" (or low intellect), a group characterized by "medical insufficiency" (or poor constitutions), a group with marked psycho-pathology (as revealed by psychological referrals and institution records), a group of "gynandrophrenes" (gynandromorphic and "arty" boys), and a group of "primary criminals" who are sound, healthy young toughs. These groupings, while inadequate for some purposes, avoid the usual blanket descriptions and include the social, psychological and medical misfits normal to a criminal group. Except for emphasizing the excess of mesomorphy, Sheldon otherwise avoids putting all of his yeggs in one basket.

In discussing psychiatric classification, Sheldon criticizes the symptomatic basis of present diagnosis as shown by repeated reclassification of some patients. As an alternative, he proposes an "operational classification." There are three extremes or "psychiatric components" in this system — a manic extreme, a paranoid extreme, and a hebephrenic extreme. The psychiatric rating is accomplished in terms of each of these components, and the final index (called ψ) is a three-number rating. Sheldon feels that the extreme values of these psychiatric components are attained by certain physique groups; the manic group approaching the somatotype 5-5-1, the paranoid group approaching the 1-5-5, and the hebephrenic extreme approaching the 5-1-5. The mid-range physiques, he reports, may go psychotic in any direction, or may shift symptoms repeatedly. Studies of the somatotype distribution of psychotic patients (at Elgin, Ill.) indicate that the three components of physique show marked negative correlations with the paranoid, the hebephrenic, and the manic psychiatric components, respectively.

Relationships between physique and disease are also considered with the aid of somatotype distribution charts of hospitalized patients. Ectomorphy, Sheldon feels, is rarer in the general hospital population than in the public at large, but more common in mental institutions. On the other hand, the massive physiques seem to be more common among patients with cancer of the breast, cancer of the uterus, and in cardio-vascular disorders (this last association is confirmed by the reviewer's own research). The author contends that

the massive physiques contribute disproportionately to both medical and social "delinquency."

The parents have also been subjected to scrutiny. The fathers, Sheldon finds, were as delinquent as the boys and the 200 heavy, often alcoholic, mothers reared a total brood of 919 children, usually on welfare funds. "As a group those 200 boys were neither better nor worse than their parents, but were reflecting with astonishing accuracy the same level of life and usefulness that had been attained by the parents even though about half of the boys had been reared apart from their parents" (p. 780). There is no evidence that medical, sociological, and psychiatric aid—though given with a lavish hand—ameliorated the problem at all: if there is, Sheldon does not give it.

In this volume Sheldon considers environment more extensively than in the previous two books in the series, though he regards any attempt at differentiation to be a chicken-or-egg problem. As an example, in discussing a tubercular youth of tubercular parents, he questions both the wisdom of allowing them to reproduce themselves, and (they having done so) the wisdom of allowing the boy to remain in that environment until he, too, became tuberculous.

In the final chapters, the author assumes the mantle, and preaches, more like Jeremiah than Hosea. It is his thesis that both medical and social "delinquency" stems disproportionately from certain physiques and that society, mindless of the future, actually sponsors the continued reproduction of these individuals. His remedy for delinquency is partly eugenic, partly economic, and partly "religious" (to Sheldon, "religion" is concern for the future). He does not put much faith in rehabilitation, partly because most of these youths have been "rehabilitated" yearly.

While the book is lucid and well written, there are many peculiarities of style that interfere with the primary purpose of communication. There is justification of the abbreviations VHP, VT and VDY for the three books in the series and possibly some justification for other alphabetizations, but they mount up appallingly. When the reviewer reached the DAMP RAT syndrome (an acrostic) the loss of seriousness seemed to counteract the economy of space, and the repeated reference to the deity as "Mr. G" seemed not impious, but of no particular merit. Literary style is admittedly a poor thing to criticize, especially in a field where its absence is often a sign of scholasticism, but it does seem that Sheldon is too flip at times and that his word-play may estrange the serious reader.

Then, too, the somatotype ratings given to some of the delinquents characterized by medical insufficiency merit further explanation. It is

Sheldon's opinion that these physiques are abnormal, "asthenic mesomorphs" or "scrub mesomorphs." But the reader who has not conducted constitutional studies in hospital or institutional series cannot evaluate that claim, and in the absence of the necessary explanations and amplifications, he is likely to feel that Sheldon was bent on calling them mesomorphs at any cost. It is unfortunate that these ratings were not explained more adequately so that the data could be checked by other observers.

Judging from the impact of the previous two books on contemporary physical anthropology, the present volume will undoubtedly stimulate research and interest as well as much discussion. But the biological thesis presented by Sheldon, and his message, will probably be ignored. Our society employs quality control in industry, but its social engineering is based on a belief in rehabilitation.

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THE NATURE-NURTURE CONTROVERSY. By NICHOLAS PASTORE. With a foreword by Goodwin Watson. King's Crown Press, New York. xvi + 213 pp. 1949. (\$3.25).

Plato defined civilization as the victory of persuasion over force. After reading the present volume there are some who might be tempted to define science, when it is applied to the discussion of human affairs, as the victory of prejudice over passion. When, as so often happens in the discussion of matters relating to mankind, the scientist dispassionately arranges his prejudices, he quite as often mistakes the results for the laws of nature. This has nowhere been more evident than in the nature-nurture controversy. Dr. Pastore has performed a valuable service in making available a succinct account of the views of 24 representative scientists who have been involved in this controversy. Twelve are hereditarians and 12 environmentalists. Dr. Pastore's purpose was to discover whether there was any significant relationship between these scientists' emphasis on nature or nurture and their particular sociopolitical origin.

Dr. Pastore found that the "varying nature-nurture emphases were significantly related to particular sociopolitical orientations; those emphasizing environmental factors tended toward liberalism or radicalism, those emphasizing hereditary factors tended toward conservatism." In fact, 11 of the 12 environmentalists were liberal or radical, and 11 of the 12 hereditarians were conservative.

Dr. Pastore's conclusion is that "the sociopolitical allegiances of the scientists were a significant determinant of their position on nature-nuture questions." The formulation of hypotheses, their mode of verification, the conclusions drawn, and the statement of their implications for society, are largely influenced by the social philosophies of the scientists. In few cases were the scientists considered "able to hold their allegiances to one side and . . . discuss problems in terms of their intrinsic scientific merits."

Those who have an intimate acquaintance with this controversial field will have no doubt of the soundness of Dr. Pastore's judgment. It is perhaps too much to hope that scientists will soon be able to rid themselves of the presuppositions which to a greater or lesser extent control their perception and interpretation of the facts. The difficulty lies, of course, not with the facts but with their interpretation. Now, whatever the kind of incense which scientists may burn before their particular shrines, it is certain that the nature-nurture problem is a spurious one. Nature and nurture are not separable categories. Hence, those who claim that one or the other is all, are wrong from the outset. A consideration of the views of the scientists treated in this volume shows that the hereditarians have more often erred in this respect than the environmentalists. Certainly the environmentalists emerge as a far sounder group than the hereditarians. But, then, perhaps that is how an environmentalist — *soi-disant* — sees it!

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INDIANS OF THE URBAN NORTHWEST. MARIAN W. SMITH, editor. xix + 370 pp., 30 illustrations. Columbia University Press, New York. 1949 (\$6.00).

This volume, a collection of studies assembled and edited by Dr. Smith, contains several papers which touch upon one aspect or another of physical anthropology, although the main interest of all the authors is clearly in the cultural field. This is a welcome sign of the increasing realization, on the part of cultural anthropologists, of the importance of varied aspects of human biology to their own speciality.

The short paper on "The Harrison Lake Physical Type" by H. Codere, provides no new information concerning these people, who are the shortest in this part of the world, but deals rather with their apparent disinterest in this, to us, distinctive characteristic. It is

assumed, rather than demonstrated, that there have been few or no changes in physical characteristics among them in the two generations which have elapsed since Boas measured a short series of adult males in this area. Actual measurements would have been most helpful, especially since the subjects must include offspring of those examined by Boas.

There is, furthermore, a paper on the food habits of (apparently) the same group, and the possibility of relationships between diet and physique could have been examined. This paper is "Diet of a Food-Gathering People, with Chemical Analysis of Salmon and Saskatoons," by T. Rivera and the editor. It is mentioned that records of quantity and methods of preparation were made; they are not, however, published. The chemical analysis of samples shows that salmon, as prepared by the Indians, is an excellent source of fat, calcium, phosphorus, and vitamins A and D; while the dried berries locally eaten contain really high concentrations of iron and copper. It is unfortunate that the further step of determining the mean amounts of these essentials actually consumed by various individuals of stated age and sex was not taken, since it would seem that the data was available to the authors.

The necessity for closer cooperation, both in field collection and in later analysis of data, between individuals trained in the various techniques of anthropology is pointed up sharply by such omissions as are above noted. In all probability, however, one would not realize the lack of such potentially fruitful collaboration, were it not for the fact that its possibilities are shown by the inclusion, in this volume, of the two papers singled out for specific mention.

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THE AWAKENING VALLEY. By JOHN COLLIER, JR., AND ANÍBAL BUITRÓN. The University of Chicago Press, vii + 199 pp. 1949 (\$6.00).

A picture book of this type is the equivalent on paper of the documentary film on the screen. As we leaf through the generous-sized pages the subject passes in review in an orderly fashion; and pausing at intervals to read, we find the brief but lively text provides the commentary. Just as in the movies, the printed pictures furnish many details that are not specifically mentioned by the commenta-

tor. These details speak more vividly to the readers who are experienced in the Latin-American field.

The first picture — a panorama — opens to 24-inch length. On the opposite page the text begins: "This is the valley of Otavalo in Ecuador . . . The rise of the Indians of Otavalo is a unique story." Then on succeeding pages the reader sees the faces of these Indians, goes to market with them, follows them back to their homes, sees their community life, and glimpses the changes taking place in their economy. The final picture shows once more the valley — this time when the shadows have lengthened. With this the commentators conclude that "The destiny of the Andes is in a revival of Indian vitality that will open the doors to individual freedom and national unity."

Obviously there is much more of special interest in all this for the Indianist and ethnologist than for the physical anthropologist. Yet the latter will profit by studying the fine portraits of these Indians. To the reviewer, who has visited the highlands of Mexico, Guatemala and Peru, it seems that scarcely more than a slight change of costume would be needed to make this set of pictures apply to any of these areas.

T. D. STEWART

U. S. National Museum



MALE ANTHROPOID GENITALIA.—The present study has led to some important general conclusions as regards the gorilla's position among the apes and its affinities to man. These are somewhat at variance with the present trend of thought among certain authorities who, on the strength of the characters of the external genitalia, have been constrained to rule out the Pongidae as possible phyletic cousins of *Homo*. The argument is a strong one as far as *Pongo* and *Anthropopithecus* are concerned, but obviously does not apply to *Gorilla*, whose male genitalia show the same tendency to foetalization as in *Homo*, to a lesser degree, perhaps, structurally (e.g., retention of os penis), but to a greater degree as regards size.

The facts here brought forward tend to support the view recently expressed by Wood Jones (1948) that the anthropoid apes are morphologically primitive compared to the Cynomorpha, and that *Homo*

is more primitive still. The male genitalia of *Anthropopithecus*, however, indicate that it is the most specialized member of the family in its sexual anatomy, whereas *Gorilla* is, next to man, the most primitive.—W. C. Osman Hill and L. Harrison-Matthews. The male external genitalia of the gorilla, with remarks on the os penis of other Hominoidea. *Proc. Zool. Soc. London*, vol. 119, pt. 2, 1949, pp. 363–378.

XANTHOMATOUS FAMILIES WITH ATHEROSCLEROSIS.—Familial xanthomatosis is by no means a rare disorder. It has long been so regarded only because its two most striking manifestations, xanthoma tuberosum and xanthoma tendinosum, are met with infrequently . . . a close relation exists between this hereditary disorder and atherosclerosis . . .

. . . it appears that the common disorder for most patients with coronary atherosclerosis may be a hereditary disturbance of cholesterol metabolism manifested by elevated serum cholesterol. Familial xanthomatosis is the severest form of the inherited disturbance. Xanthoma lesions develop only in patients who carry two abnormal genes for cholesterol; that is, they are homozygotes. Atherosclerosis is frequent in such persons. Many patients with uncomplicated coronary artery disease are probably affected with a milder form of disturbed lipid metabolism. They carry one abnormal gene for cholesterol; that is, they are heterozygotes. Derangement of cholesterol metabolism helps explain the familial incidence of coronary artery disease and also accounts in part for its development in many persons under 50 years of age.—David Adlersberg, Albert D. Parets and Ernest P. Boas. *Genetics of Atherosclerosis*. *J. Am. Med. Assoc.*, vol. 141, no. 4, Sept. 24, 1949, pp. 246–254.

ON THE RELATIONSHIPS OF EARLY PRIMATES

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ONE FIGURE

In this paper, early primate evolution is approached in terms of two concepts of paleontology: adaptive radiation and adaptive zone (Simpson, '44). The adaptive zone of Paleocene and Eocene primates is arrived at by using criteria of structure and of faunal relationship. It seems to have been very generalized and wide, covering what might be called a *primate-rodent* ecologic niche.

The evolution of early primates is however a small part of general mammalian evolution, and must be viewed as part of the general evolutionary sequence. The concept of a *radiation pattern* may be used for this purpose. In terms of it, faunal evolution is seen as a series of cycles, each cycle consisting of: (1) A period of major radiation, in which a large number of forms differentiate quickly and enter the main adaptive zones. (2) A period of reshuffling, with development and extinction of lines within zones. (3) Once established within a single adaptive zone, the evolution of a group appears in the main to follow the "orthogenetic" pattern of phyletic evolution. (4) This will continue until a new cycle starts with wholesale extinction of older forms and radiation of new groups into the main adaptive zones (Simpson, '44).

As a working hypothesis, placental evolution may be seen to consist of three such major radiations (Olson, '43). The first, which started at the close of the Age of Reptiles, consisted primarily of insectivore groups and close derivatives. Before this radiation had filled the major adaptive zones, the

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second radiation of placentals started, and the archaic ungulates and carnivores successfully invaded the main adaptive zones, in part, probably, in competition with the earlier insectivores. The forms representing the first radiation then became restricted to certain secondary "refuge areas" in the ecology, where they in part survive to this day.

The primates are such an early, insectivore-derived stock (Olson, '43). In what follows, the order will be discussed primarily in terms of the problem: What was the early primate adaptive zone, and in what respects was it restricted through competition with later forms? On the basis of answers to this, inferences may be drawn as to the nature and mode of the evolution which took place, and the evolutionary relationships of the group.

The only materials available for the solution of this problem are paleontological, consisting of the fossil primate material from the Paleocene and Eocene, interpreted in the light of general knowledge of the associated faunas. Primates are poorly represented in the fossil record, mostly by very fragmentary material. Even so, some 55 genera from the Paleocene and Eocene have been defined, many of which can be related in phyletic lines. The present paper will not attempt to discuss the classification of all these forms; Simpson (40, '45) is followed. A summary chart of generic names and relationships is appended (fig. 1).

An apparent taxonomic difficulty is inherent in this approach: early primates are considered as a unit, in spite of the common practice of subdividing them into lemuroids (Adapidae) and tarsioids (Anaptomorphidae). The general diffuseness of this distinction is however suggested in Simpson's classification by the great number of unplaceable genera, often anatomically comparatively well known; Adapidae, *incert. sedis* three genera; Anaptomorphidae, *incert. sedis* three genera; Prosimii, uncertain family, 9 genera. Furthermore, the definitions and boundaries of the groups are not agreed upon by leading authorities (Simpson, '45).

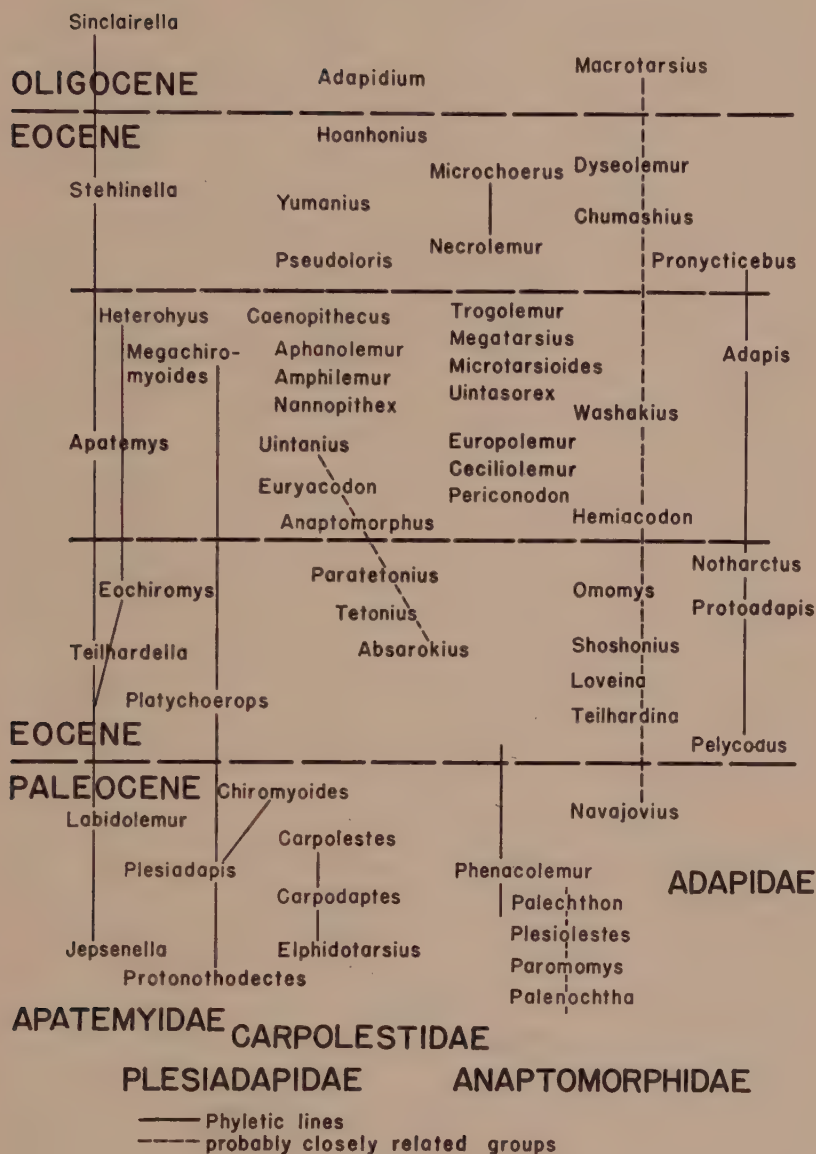


Figure 1

In the Anaptomorphidae (tarsioids) are united some 28 genera for reasons in large part negative (Simpson, '40). They are enough alike in known parts to be related, but there is little or no evidence showing that this affinity is real. One has, more or less, a continuum from anaptomorphid tarsioids to lemuroids: *Tarsius* is closely similar to *Pseudoloris*, which is related to *Necrolemur* and *Tetonius*. These are linked through dental similarities with *Omomys* and *Hemiacodon*, which in turn have many dental features in common with lemurs, e.g., *Pronycticebus*. The inclusiveness of one or the other family is thus arbitrarily determined by where one draws the line.

Geographical or temporal grouping of forms does not make the picture any clearer. This suggests that the strict separation of lemuroids vs. tarsioids was not present in Eocene times, and that all these forms may be grouped together. In this scheme, *Tarsius* would be regarded as an aberrant survivor of a specialized lemuroid stock, possibly descended from *Pseudoloris* or *Necrolemur* (Simpson, '40). In view of the general vagueness of subfamily and family distinctions, this seems the only reasonable conclusion, and the orthodox insistence upon the distinction is more a reflection of the bias that results from comparisons of the modern descendants.

NATURE OF THE EARLY PRIMATE ADAPTIVE ZONE

A determination of the early primate adaptive zone may then be based on the following types of evidence:

1. Structure — progressive specializations of structure occurring in a phyletic line, of probable adaptive value in a specific habitat.
2. Coexistence — the presence of several genera of primates in the same area over a considerable length of time, demonstrating ecologic differentiation.
3. Composition of fauna — the nature of the adaptive zones probably inhabited by other forms in the fauna, indicating what ecologic niches might be left for primates to inhabit.

4. Frequency — the percentage frequency of identified primate individuals in a fauna, showing size and nature of the primate zone.
5. Temporal distribution — the sequence of main deployment of primate families in relation to potentially competing forms.

1. *Structure.* The families Adapidae and Anaptomorphidae show many typical lemuroid and tarsioid specializations. They seem in great part to have been arboreal, frugivorous or semi-omnivorous small animals, adapted to the same ecologic niches as modern lemurs and tarsiers. A typical form is *Notharctus* of North America. Hopping adaptations were developed in *Hemiacodon*, with tarsal elongation similar to that of *Tarsius*, but anatomically on a different pattern (Simpson, '40). The Adapidae thus seem to be related to modern lemurs, and to represent essentially the Eocene stock from which modern lemurs may have arisen.

Certain groups within these families show strongly divergent structural adaptations. In the subfamily Paromomyinae two large anterior teeth are developed. The subfamily Necrolemurinae show similar adaptations, in this case only one enlarged incisor on each side. Occasional other genera of the family show rodent-like enlargement of the anterior teeth. In the phyletic series *Necrolemur-Microchoerus* there is furthermore a progressive trend of molar specialization in which a number of cusps are elongated to form anterior-posterior, almost loph-like ridges. From general parallels, one would expect this to be an herbivorous, probably browsing adaptation.

Rodent-like specializations are carried much further in other primate families. The Apatemyidae have a geologic range from Middle Paleocene to Lower Oligocene, and show a progressive development of rodent-like characters. Already in the earliest form, *Jepsenella*, the lower incisor root extends below the second molar; and in the last member of the family, *Sinclairiella*, the skull shows consistent pseudo-rodent adaptations (Jepsen, '34).

A similar divergent family is the Plesiadapidae, ranging from Middle Paleocene to Middle Eocene. Late genera show extreme specializations, to the extent that the genus *Megachiromyoides*, for example, has been placed variously among primates, insectivores, and rodents. It undoubtedly represents the last of a very aberrant lemuroid phylum (Simpson, '40). The type genus, *Plesiadapis*, is well known from descriptions by Simpson ('35). Parallelism with rodents is shown in the prominent incisors and in the development of the angular process, which is hook-like and projects backwards and slightly downwards.

A third highly aberrant family is the Carpolestidae of Middle and Late Paleocene. In these forms the premolars have been developed into a long, sharp-edged pair of shears, and in this, as well as in a number of other dental characteristics, the group shows striking similarity to the modern kangaroo rat (Abel, '31). This form is adapted to a diet of grass and roots for which it burrows. The deduction that *Carpolestes* represents a burrowing, root- and grass-eating, terrestrial primate does not seem unreasonable. The family is characterized by Simpson ('40) as "another sterile offshoot of a poorly differentiated, proto-lemuroid stock."

On morphological grounds it might therefore be deduced that primates in Early Tertiary times successfully inhabited a great variety of ecologic niches, as demonstrated by the existence of insectivorous (*Tetoniuss*), frugivorous (Adapidae, most Anaptomorphidae), and herbivorous (*Microchoerus*) arboreal forms, as well as arboreal, terrestrial, and burrowing rodent-like forms (Apatemyidae, Carpolestidae, etc.). So wide an adaptive zone would tend to produce a large number of genera and a frequent development of divergent and convergent phyletic lines, all of which is confusingly true in the fossil record.

2. *Coexistence*. According to this one would further expect a number of primate genera to coexist in one area over long periods of time, filling different ecologic niches and not entering into direct competition with one another. In most Paleo-

cene and Eocene faunas this is the case. Any discussion of Paleocene faunas is, however, made difficult by the nature of the record: most primates occur in small, isolated pockets and quarries, possibly carnivore dens, and general collecting does not turn up the same abundance and richness of forms. The following suggestions must therefore be regarded as very tentative. In the Late Paleocene Tiffany fauna (Mesa Pocket) of North America, 6 genera (more species) of primates are found together with two carnivore genera, one condylarth, etc. (Simpson, '35). In the Late Paleocene faunas of Bear Creek and Scarett Quarry, three genera are found; in Silver Coulee and Clark Fork, two genera. General collecting from the Tiffany surface, Plateau Valley, and Paskapoo has as yet only turned up one genus, namely *Plesiadapis*. This is however found in great abundance. Of the total number of genera present in these Upper Paleocene faunas of the Rocky Mountain area, primates constitute more than 10%, which can hardly be paralleled in any modern fauna.² A very wide adaptive zone is thus indicated for the order.

3. *Composition of fauna.* The other members of these early faunas might by their adaptations suggest by elimination what ecologic niches were open for primates to inhabit. In the above Tiffany fauna of Mesa Pocket, carnivores, condylarths, amblypods, multituberculates, marsupials, insectivores, and a possible bat are represented (Simpson, '35). Rodents are not found in this fauna, and are completely unknown in Early and Middle Paleocene. This leaves an adaptive zone open in which multituberculates, primates, and possibly insectivores could compete. Primates are thus in no way excluded by more highly specialized forms from the wide adaptive zone deduced on morphological grounds.

4. *Frequency.* Inhabiting this broad adaptive zone, primates should be a dominating group in the local faunas of the Paleocene, not only in number of genera, but also in the total number of individuals present. In spite of the adverse fossili-

² This discussion of Paleocene faunas is primarily based on private communication with Bryan Patterson.

zation conditions for the arboreal representatives of the order, this is quite frequently the case. Of the total number of identified individuals in collections from the Ft. Union, Middle Paleocene, of Montana (although not in the New Mexico facies), primates constitute 20%. Other groups are: multituberculates, 25%; insectivores, 15%; carnivores, 15%; condylarths, 25%. This count is furthermore biased towards a greater number of multituberculates, since all such were identified (Simpson, '37). As mentioned above, the form *Plesiadapis* is quite common, to the extent of being the type fossil of the level. It is clear from this that the primates must have played an incomparably greater role in Paleocene faunas than in any modern fauna, and the explanation must be sought in a difference in ecologic habitat.

5. *Temporal distribution.* As the last type of evidence, the time of appearance, deployment, and extinction of early primates indicates the competitive relations of the group. Rodents appear first in the Late Paleocene, after which time no new group of primates evolved clear rodent-like adaptations (the Middle Eocene genera *Trogolemur* and *Uintasorex*, with strong incisor development are questionable exceptions, since their ancestry is not established). All primate families with rodent-like adaptations were thus established by Middle Paleocene, before the appearance of true rodents. The main spread of rodents came in the Eocene, and coincided with the decline and extinction of primitive primates in North America and Europe.

Multituberculates constitute another possible competing group in part of the primate-rodent adaptive zone. Numerous adaptations towards an herbivorous and frugivorous diet are evident (Simpson, '26), many of them superficially rodent-like. Although probably quite specialized in their adaptations, they exploited the same food source as many early primates, who were thus forced to compete for this food. However, the main flowering of the order Multituberculata was before the primate radiation, and the main deployment of primates is correlated

with the decline and extinction of multituberculates, of which the last family lingered on until Early Eocene.

The radical reduction in number of genera of primates in Late Eocene times, and their complete disappearance from Europe and North America by Middle Oligocene, was probably due to a number of factors. Through rodent competition the primate adaptive zone was seriously limited, and the order as a whole driven into an arboreal "refuge area." The progressively colder climates through Eocene and Oligocene may then have driven the jungle, and thus the arboreal primates, out of the more temperate areas where most of the collecting of the fossils has been done. On the other hand, even modern lemurs, which have gone considerably farther in brain evolution than had their Eocene predecessors, today flourish only in geographically isolated refuge areas like Madagascar and the East Indies. Thus even these forms are not able to compete in a fauna with full representation of modern mammals, where they presumably are replaced mainly by monkeys. More progressive groups of monkeys were thus probably a decisive factor in the extinction of lemuroids over large areas in Early Tertiary times. That the group, if left alone, retained capacities for highly divergent evolution is strikingly shown in the Pliocene-Pleistocene lemuroid radiation on Madagascar, where large, ungulate-like herbivores were developed.

CONCLUSIONS

It thus seems that primates took prominent part in the first placental radiation, invading a broad *primate-rodent* adaptive zone, and developing a large number of genera and phyletic lines. In ecologic habitat, many of these early primates may be thought of as the rats of the Paleocene. With the later appearance of true rodents, the primate habitat was however markedly restricted, and the order became, as did most orders of the early placental radiation, in part extinct and in part limited to an ecologic refuge area — arboreal habitat. In this restricted niche, competition led to the extinction of more conservative forms, and new adaptations were developed in the

more progressive lines. Only in the isolated areas of Madagascar and the East Indies do the less modified descendants of the arboreal early primates persist today in the form of various lemuroid groups and *Tarsius*.

This modification of our picture of the early primates adaptive zone has also certain wider implications, since it invalidates the naive technique which uses gross morphological resemblance as an index of relationship between early and later primates. In invading their early, wide adaptive zone, the primates were taking part in the first placental radiation. They were thus in a different phase of evolution from the later primates (which were evolving within a zone), and were for the most part adapting to a radically different adaptive zone from that inhabited by modern monkeys. A major shift in adaptive zone separates the two groups.

Early primates, by virtue of participating in a major radiation, show a great deal of variation in all preserved features, and within and between families abundant examples of parallelism and convergence can be demonstrated. From this pool of variability later primates were undoubtedly drawn. But because of the limited overlap in adaptive zone one would expect reversals of trend in phyletic lines and delusive patterns of parallel evolution. Morphological features, whether "adaptive" or "non-adaptive," thus cannot be used by themselves as a measure of relationship between early and later primates. They are only meaningful in the context of phyletic lines, where the adaptive shift can be demonstrated and traced.

SUMMARY

Early primate evolution can be approached through the paleontological concepts of adaptive radiation and adaptive zone. The problem — the adaptive zone of Paleocene and Eocene primates — is discussed on the basis of various criteria of structural and faunal relationships. In numerous lines of early primates, chisel-shaped incisors, large diastemata, and grinding molars were developed independently (*Apatemyidae*, *Plesiadapidae*, various *Anaptomorphidae*). Other groups

show root-eating (Carpolestidae) and browsing (*Microchoerus*) adaptation. In Early Tertiary faunas primates furthermore play an important role, constituting more than 10% of all late Paleocene mammalian genera from the Rocky Mountain area, and 20% of the total of identified individuals from the Mesa Pocket, Ft. Union fauna of Montana. The conclusion is that early primates inhabited a very broad *primate-rodent* adaptive zone, many of them constituting the "rats of the Paleocene." As a consequence of limited overlap in the adaptive zone, gross morphological resemblance between early and later primates cannot be used as an index of relationship, which constitutes an important limitation upon the comparative method.

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EARLY STUDY IN PRIMATOLOGY.—In comparing the structure of the ape [i.e., monkey] and man Severino [1580–1656] considers that their affinity is so patent that the ape should be exploited for medical purposes, and therefore stress is laid only on the points of difference.—F. J. Cole. *A history of comparative anatomy from Aristotle to the Eighteenth Century*. London, 1944.

REQUEST FOR DATA ON THE ERUPTION OF DECIDUOUS TEETH.—In connection with researches on the eruption of teeth in man, it has become evident that presently available literature does not contain sufficient data for computing the precise degrees of variability for different classes of deciduous teeth. What figures have been published need confirmation. The undersigned is now engaged in an extension of the researches reprinted in the Yearbook for 1948, and would appreciate data from any member of the Asssocation who has kept a record of tooth eruption in his own children, or any other children. The following form is suggested for copying the information needed.

Birthdate..... Sex.....

Full term baby?.....

Premature.....months.....weeks, approximately.

Date when any part of a deciduous tooth crown was first noted above the gum:

	Child's right	Child's left
Lower central incisor
Upper central incisor
Lower lateral incisor
Upper lateral incisor
Lower first molar
Upper first molar
Lower canine
Upper canine
Lower second molar
Upper second molar

This information would be extremely valuable in the study now in progress at this institution.

V. O. HURME, D.M.D.
Director of Clinical Research
Forsyth Dental Infirmary for Children
140 The Fenway, Boston 15, Mass.

MAN CONTEMPORANEOUS WITH THE SWARTKRANS APE-MAN

R. BROOM AND J. T. ROBINSON

Transvaal Museum, Pretoria, South Africa

SIX FIGURES

At Taungs, Sterkfontein, Kromdraai and Swartkrans we have four distinct types of ape-men. At Makapan we have a fifth type which Dart has called *Australopithecus prometheus*; but this seems to be so nearly on the borderline between ape-man and man that on the evidence we have we cannot be quite certain which to call it.

At Taungs only one ape-man skull has been found—the famous *Australopithecus africanus*—and no definite trace of contemporaneous man has been discovered. At Kromdraai we have the type skull of *Paranthropus robustus* and the young child jaw, but no evidence of man. The deposit where the type skull was found was of very limited extent and the negative evidence thus not of much weight.

At the main cave at Sterkfontein extensive work has been done. We have discovered the remains of over 20 individuals of *Plesianthropus transvaalensis*; but we have found no tooth, bone or implement that would suggest contemporary man. If the deposit is of Upper Pliocene age, as seems probable, we may consider it probable that some type of early man may have been contemporary. All we can say is that so far we have found no evidence of man.

At the Swartkrans cave, though the deposit we have worked through is not more than about 200 cubic yards, we have found jaws and teeth of at least 10 different individuals of the large ape-man *Paranthropus crassidens*.

On April 29th, 1949, in a pocket on the edge of the main deposit, the junior author discovered the mandible of what appears to be an early type of man. We have called it *Telanthropus capensis*. The mandible is nearly complete though a little crushed, and there are 5 molars, well preserved but slightly worn, and the sockets of all the other teeth.

Very manifestly the jaw is not that of *Paranthropus crassidens*. It is very much smaller, as are the teeth, and the ascending ramus, though broad, is not high as in the ape-man. The teeth are not those of a species of *Homo*, though the

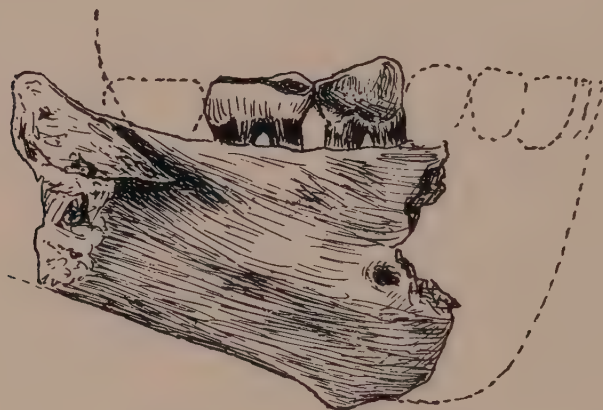


Fig. 1 Outer view of right side of human jaw fragment from main *Paranthropus crassidens* deposit at Swartkrans. Natural size.

first and second molars are human in size, and the third molar is well developed. The jaw appears to be that of an early type of man — possibly of Pliocene man.

It is unfortunate that we cannot give any more precise dating to the jaw. The pocket in the main deposit is somewhat different in material and must be of later date, but it may not be geologically much later. There were no bones of mammals associated with the jaw except those of some small rodents which do not help us much. There was no other bone or tooth of this early man found except an isolated first pre-molar, which probably belongs to the same jaw.

Just recently, however, we have found in the main deposit, and certainly contemporaneous with *Paranthropus crassidens*, a considerable portion of a lower jaw and a few isolated teeth of man. The jaw was broken before being fossilised. The part preserved is in good condition, uncrushed and with the first and second molars present but somewhat worn.

The jaw is not very different in size from that of *Telanthropus capensis*, but it seems to differ in a number of characters; owing to the crushing of the latter it is difficult to make

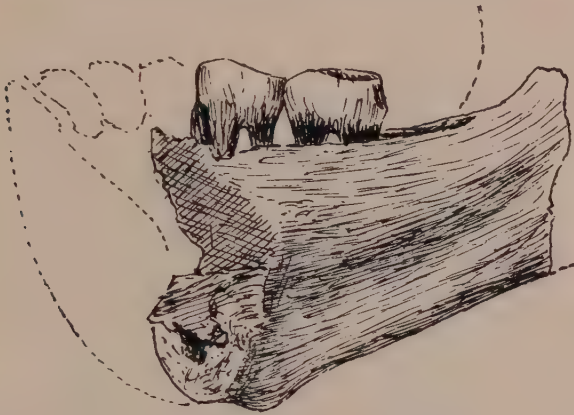


Fig. 2 Inner view of jaw. Natural size.

comparisons. Though the front of the jaw is lost we can make a restoration with some confidence from the curves of the part preserved. There was clearly no simian shelf, and the front of the symphysis was probably rounded as shown in figures 1 and 2. The photographs, figures 4 and 5, show the jaw in its actual state.

The jaw is rather deep at the front of the horizontal ramus but not more massive than in most modern human jaws. In the region of the first molar the width of the ramus is 14.7 mm. The lower border of the jaw, in about the plane of the mental foramen, has a little flattened descending process. In the Heidelberg jaw in the same region there is a downward ex-

tension of the border of the ramus, but here it is as thick as the rest of the lower border.

The mental foramen is in about the same vertical plane as the front of the first molar tooth. The photographs show all we have of this human jaw. The first and second molar teeth are fairly well preserved but the top of the crown of the first is badly worn and that of the second considerably worn (see fig. 6). The first measures about 12.3 mm in length, and the second, 12.9 mm in length and 12.3 mm in greatest width.

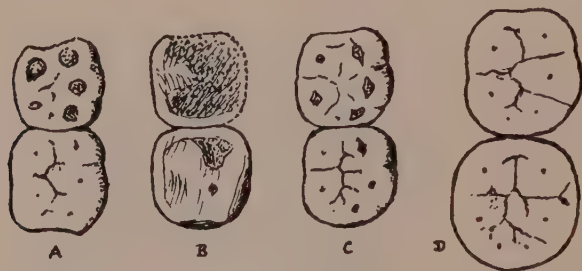


Fig. 3 Occlusal views of first and second right lower molars

A. *Telanthropus capensis* (first molar is left tooth reversed).

B. Human jaw associated with *Paranthropus crassidens*.

C. *Homo sapiens* (Bantu).

D. *Paranthropus crassidens*, type. (Second molar is left tooth reversed.)
Natural size.

From the very little evidence we have we are not in a position to discuss the affinities of this jaw or even to say whether it is the same species as the *Telanthropus capensis* jaw. We may later get a good jaw and perhaps a part of the skull. At present we can merely say that the jaw is manifestly not that of a *Paranthropus crassidens*, and that it appears to be the jaw of an early type of man. A figure is given of the occlusal surfaces of the molars and, for comparison, the corresponding teeth of *Telanthropus capensis*, a Bantu and *Paranthropus crassidens*.



Fig. 4 External view



Fig. 5 Internal view

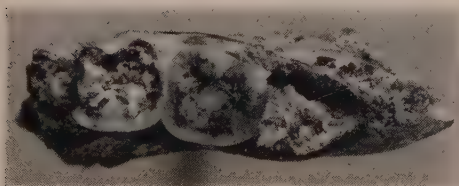


Fig. 6 Occlusal view.

Figs. 4-6 Human jaw fragment from the main *Paranthropus crassidens* deposit at Swartkrans. All photographs natural size.



RELATIVE USEFULNESS OF VARIOUS MEASUREMENTS.—At the conference on anthropometric technique held at the second *Congrès international des Sciences anthropologiques et ethnographiques* (Copenhagen, 1938) we agreed upon the need for a standard list of characters for general use in the measurement of racial series, living and cranial.

Clearly, such a standard list should include those characters that are in general most useful in helping students of race to discriminate between different populations, namely those that vary most as between races compared with their variation within racial units.

As a basis on which to calculate the relative usefulness of characters from the above point of view, we have sought answers to the following question: supposing the variability of a character were the same in all races, with a standard deviation equal to its estimated mean intra-racial value σ_{ir} ; and supposing samples of 100 were taken from pairs of different races at random; how big a proportion, in the long run, of differences between sample means would fail to indicate a difference between the populations from which they were drawn? . . .

. . . as regards the nose, it is estimated that only 12 per cent of comparisons between two samples of 100 from different "races" would fail to reveal a significant difference in mean nose-breadth, while as many as 18 per cent would not differ significantly in nose-height. The corresponding estimate for head-breadth is 15 per cent as against 20 per cent for head-length; in the case of the upper face, it is 18 per cent for breadth (bizygomatic) and 24 per cent for height; for hand-breadth it is 11 per cent, for hand-length 15 per cent. Indeed, if our 65 and 71 means of hand-breadth and length provide us with a good enough sample of the different races, the hand would seem to be as good as the nose, or even better, for marking off one race from another.

Again, minimum frontal breadth differs less from race to race (relative to its intra-racial variability) than does maximum head-breadth, the figures being 20 per cent and 15 per cent respectively; and stature (19 per cent) rather less than sitting height (17 per cent), it seems.—Miriam L. Tildesley. The relative usefulness of various characters on the living for racial comparison. *Man*, vol. 51, no. 14.

A VIEW OF SOMATOLOGY AND SEROLOGY IN MICRONESIA

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FIVE FIGURES

In 1933, Shapiro wrote: "It is regrettable that so little is known of the physical characteristics of the Micronesians." Now, however, this subject is better understood, largely as a result of more recent Japanese writings. Since this newer literature is not yet fully appreciated outside Japan, a review of the field seems especially timely now that several Americans have begun anthropometric research in Micronesia (Murdock, '48a, '48b).

The review which follows describes Micronesia first as a geographic unit, together with a regional classification of its people. Their morphology in both skeletal and living series comes next, along with the theories of Hasebe ('38) on their racial history. Local differences in the distribution of the ABO blood groups in Micronesia make it possible to test Hasebe's scheme in some detail. The physical and serological evidence is then used for delineating a possible Polynesian migration route through Micronesia. The final section of this paper deals with American somatological studies in the Trust Territory since the war, including my own, and with the possibilities for further research in the area.

THE GEOGRAPHY AND PEOPLES OF MICRONESIA

Micronesia consists of many tiny islands in almost empty ocean, centrally located in the Pacific. It joins Indonesia to the west, Melanesia to the south, and Polynesia to the east.

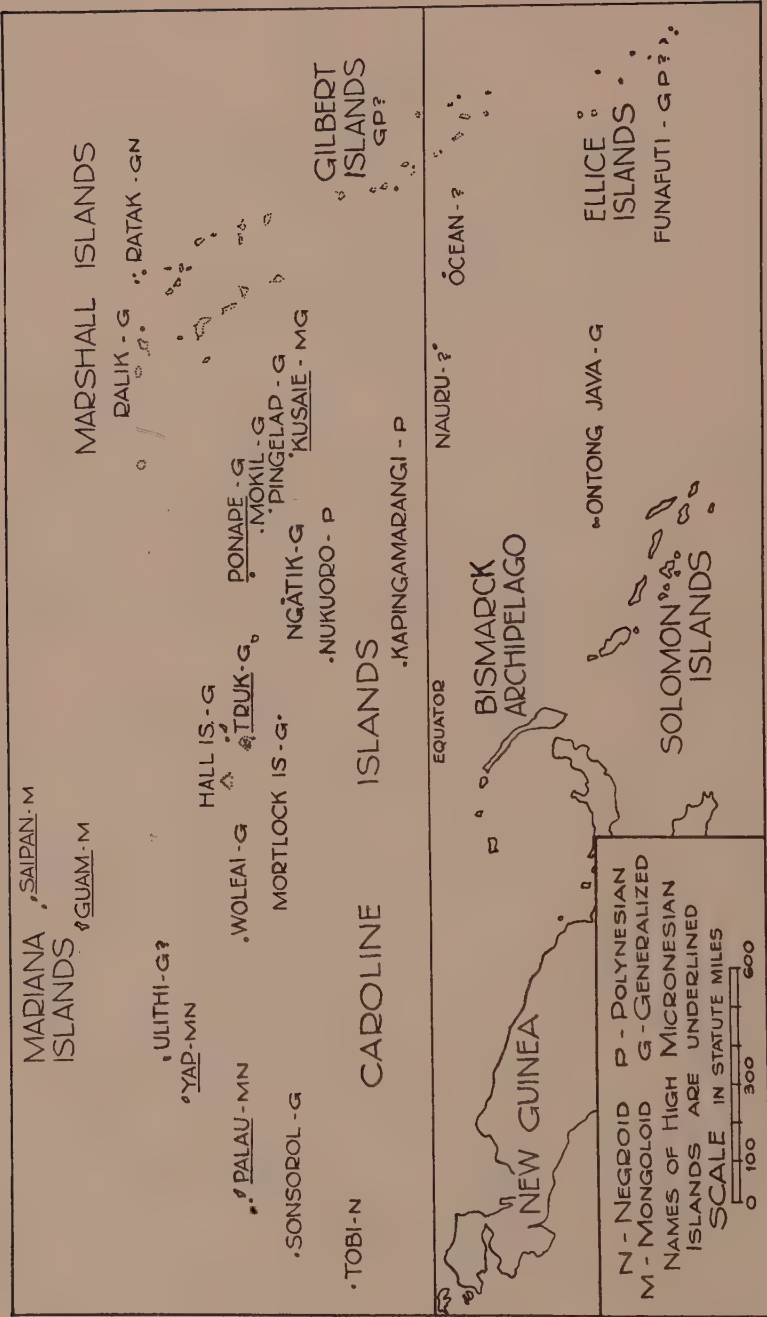


Fig. 1 Present racial affiliations in Micronesia.

These adjacent areas are racially and culturally more distinctive than Micronesia, which is mainly intermediate. Indeed, the major problem in the racial history of Micronesia is to work out the timing and sequence of human migrations affecting both Micronesia and these neighboring regions.

The larger land masses in Micronesia are generally hilly, high islands or island groups. Going from west to east, these high islands include the Palaus, Yap, the Marianas, Truk, Ponape and Kusaie. The greater size and fertility of these islands allow a more diverse supply of food plants, larger human populations, and more complex social groupings than on the low islands.

The smaller islands are mainly low-lying atolls. Their sandy and calcareous soils can support relatively few food plants, and the land area for human occupation is severely limited. Among the low islands to be mentioned here are Tobi and Sonsorol to the southwest and the Western Caroline atolls extending from Ulithi to the Hall Islands north of Truk. The Eastern Caroline atolls include the Mortlocks southeast of Truk, Ngatik, Mokil, Pingelap, Kapingamarangi and Nukuoro. The Marshall Islands to the northeast include the Ralik group to the west and the Ratak group to the east. South of the Marshalls are the Gilbert and Ellice Islands.

Southwest of the Marshalls are Nauru and Ocean Islands. Since no anthropometry has been done there to my knowledge, these two islands will not be discussed further.

The peoples of Micronesia can be divided into three groups, going from northwest to southeast. First are the Chamorros of the Marianas. Second are what I call "Trans-Micronesians," in a broad band from Sonsorol and Tobi in the southwest to the Marshalls and Gilberts in the east. Third are the speakers of Polynesian languages. This last group lives on Kapingamarangi and Nukuoro in the southern Carolines, and in the Ellice Islands at the southeastern corner of Micronesia.

The first of these three major groupings, the Chamorros, are a distinctive and highly acculturated people. Both physi-

cally and culturally, they are not unlike Christian Filipinos. Before the Spanish occupation of their homeland in the 17th century, however, they were quite similar to the modern natives of Yap: a socially stratified society whose members subsisted mainly on root crops, coconuts and fish, with an elaboration of shell "money" as a medium of exchange. Now little is left of this older culture aside from the Chamorro language, some of the folklore, and traditions of matriliney and class distinctions (Thompson, '45).

The "Trans-Micronesians," however, are much more conservative culturally. They live in a vast stretch of ocean nearly 3,000 miles long. Until the 19th century, they were relatively undisturbed by Europeans. Although they have since interbred with Whites and Japanese in some places, it is still possible to examine metrical series whose members seem practically unmixed with non-Oceanic stocks. Prevalent cultural features of the Trans-Micronesians include matriliney, social classes, and systems of land tenure somewhat comparable to feudalism. These features are strongest in the larger peripheral islands. The Trans-Micronesians are often skillful navigators. Their voyages have undoubtedly led to the spread of cultural ideas across the entire area.

The Gilbertese speak a language related to those of other Trans-Micronesians, but seem to be intermediate between these and the Polynesians in physique and culture.

The Polynesian speakers are racially and culturally similar to the Polynesians proper.

SKELETAL SERIES OF MICRONESIANS

Two reports, published in the same year, contain the earliest descriptions of Micronesian skulls. Krause (1881) described the larger of the two series of skulls, and Virchow (1881) the smaller. Krause's study led him to conclude that the cephalic index increases westward from Ponape to Palau, from dolichocephaly to subbrachycephaly. This finding has since been verified by Hasebe ('38) on the living and by Arai ('41) on skeletal material.

Most of the available skeletal remains from Micronesia consist of aboriginal Chamorro bones from the Marianas. Comparable material from Trans-Micronesia is less abundant, so that the racial differences between the old Chamorros and their neighbors are not yet certain.

Schlaginhaufen ('05) worked on 23 old Chamorro skulls from Saipan. His paper includes illustrations of specimens which clearly confirm his observations. These skulls were difficult to sex. Fourteen of the more complete skulls showed considerable variability in the cranial index: 5 dolichocrane, three mesocrane, and 6 subbrachycrane. Since the living series of Saipan Chamorros measured by Hasebe ('38) were, on the average, almost subbrachycephalic, it is likely that the historic Chamorros have grown more round-headed. This brachycephalization could plausibly have resulted from inter-marriage with Filipinos, Mexicans and other foreigners.

Many skulls in Schlaginhaufen's series showed anterior and lateral projection of the malars. The nasal region was low and flat, with slight alveolar prognathism inferiorly. Inca bones were common.

Cabeza Pereiro ('26) studied 4 skulls from Guam and one from Ponape. His photographs and descriptions of the series confirm the observations of Schlaginhaufen, although all 4 Chamorro skulls were dolichocrane.

At the Bishop Museum in Honolulu is a series of over 100 skulls and numerous postcranial bones, collected during archaeological excavations in Guam by Hornböstel and Thompson. These remains come from Chamorro burials dating from just before or during the Spanish conquest. In an unpublished manuscript, Wood Jones made morphological observations on all the skulls. Leigh ('29) has studied the morphology and pathology of the teeth in 88 individuals. A metrical analysis of this material, however, has not yet been done. It would be a major contribution to Micronesian somatology.

Among the features most evident in Wood Jones' descriptions are an oval or ovoid vault, broad zygomatic arches,

often everted below, and well-defined temporal crests. Although a glabellar eminence is often seen in the males, the browridges are usually not strongly developed. The palate is broad and the teeth large. The mandible is generally massive.

The dental study of Leigh ('29) on this series indicated that less than 1% of the teeth were carious. Most individuals older than 35 showed periodontal disease and a loss of some teeth. The teeth were usually stained with betel, even after centuries underground. These dental conditions resemble those of modern Yap, where about 3% of the teeth are carious, and dental loss takes place at an accelerating rate after the age of 35 years.

Other work on Micronesian skeletal remains include Hasebe ('28a) and Arai ('41). Hasebe, in particular, noted that the eastern Carolinians of Ponape and Kusaie showed features reminiscent of Melanesians. These characteristics included ortho-dolichocrany, a lack of malar prominence, alveolar prognathism, and (to a Japanese), relatively long extremities.

Arai ('41) worked on skeletons from Saipan, Tinian, Palau, and Truk. He noted that the western people from the first three localities had larger skulls than the Trukese; generally brachy- or mesocrane; while the more central Trukese were more dolichocrane. This evidence confirms the similar observations of Krause (1881), which were mentioned earlier. Arai observed that the temporal and nuchal muscle attachments were fairly strong, the forehead narrow, nasion sunken, and the mandible massive. Arai, like Hasebe, noted the rather long extremities in these individuals.

The craniological evidence suggests that the aboriginal Chamorros were related to the other high islanders in western Micronesia. The vagueness of travelers' descriptions (Thompson, '45) makes it difficult to differentiate them from their neighbors to the south. As Hasebe ('38) has shown in the living, the western high islanders, including the Saipan

Chamorros, are more Mongoloid than the central Trans-Micronesians today. Indeed, the Chamorros now are metrically the most Mongoloid group in all Micronesia.

THE ANTHROPOMETRY OF LIVING MICRONESIANS

The earliest living series measured by a trained anthropometrist in Micronesia were those studied by Miklucho-Maclay (1878) on Yap and Palau. Unfortunately, however, the author cites only ranges of his measurements and not means. Hedley (1898) measured a handful of males on Funafuti in the Ellice Islands. Hambruch ('06) worked on a few natives of Truk, Yap and Palau, and so did Hirako ('28). Finsch (cited by Shapiro, '33) measured some Gilbertese, and one of the best local studies to date was done by Schlaginhaufen ('29) on Kapingamarangi.

The most comprehensive anthropometric survey of Micronesia until now is that of Hasebe. It included over 1700 individuals of both sexes in all the major islands of the former Japanese Mandate, and ranks with the work of Birdsell in Australia for regional coverage. Hasebe has published a few summaries of limited areas and of morphological features (Hasebe, '28b, '28c, '39), but his most important article so far is a preliminary description of his whole series, in Japanese (Hasebe, '38). When Messrs. Nathaniel R. Kidder and William D. Stevens, of the Harvard Peabody Museum to Yap, visited Japan in 1948, Professor Hasebe showed them this study. Through the kindness of the Allied Translator and Interpreter Section, G-2, SCAP, in Tokyo, it has been translated into English in manuscript. Professor Hasebe is now writing a major treatise on his researches. It will probably be a definitive treatment of his findings, and will deserve serious study by racial historians and other anthropologists.

As a preliminary orientation on Micronesian racial morphology, table 1 shows the distribution of certain metrical averages in the Chamorros, Trans-Micronesians and Polynesian-speakers. The sources include Hasebe ('38) for islands within the former Japanese Mandate, Finsch (cited by

Shapiro, '33) for the Gilberts, and Hedley (1898) for Funa-futi in the Ellice Islands. For convenient comparison, one column includes the compilation of Shapiro ('43) of 26 series of Polynesians.

The facial and nasal heights and indices reveal divergences among the investigators in establishing nasion. The nasofrontal suture was seldom palpable in my own series from Yap, and I therefore used the midpoint of an imaginary horizontal tangent across the superior palpebral fissures (Hooton, '46). Both Hasebe and Finsch seem to have used a higher nasion, and perhaps Hedley used a lower one. Comparisons among local Micronesian series later on will therefore be confined to Hasebe's data for the sake of simplicity. In spite of these difficulties with nasion, however, table 1 reveals several important metrical features of the Micronesians.

The table shows that the modern Chamorros resemble the Trans-Micronesians in their short to medium stature. They are near the extreme, however, in certain significant measurements: great head breadth and bizygomatic diameter, narrow absolute nose breadth, and short facial and nasal heights. These averages confirm the visual impression that today the Chamorros are the most Mongoloid group in Micronesia. How much of this specialization comes from recent admixture with Filipinos, Mexicans and others, however, is not yet certain.

The Trans-Micronesians as a group are short to low medium in stature, with considerable local differences in head form, ranging from dolichocephaly to subbrachycephaly. They differ from Polynesians in having narrower heads and shorter stature.

Although comparative studies of body build in Polynesia and Micronesia have not yet been made, it seems likely that the lateral, massive build found in many Polynesians is less prevalent in the Trans-Micronesians.

Hasebe's observations in most of the major Trans-Micronesian islands make it possible to describe the inhabitants

TABLE 1
Metrical averages in Polynesian and Micronesian adult males

Investigator	CHAMORRO	TRANS- MICRONESIANS	GILBERTS	ELLICE	KAPINGA- MARANGI	POLYNESIA
	Hasebe	Hasebe	Finch	Hedley	Hasebe	Compiled by Shapiro
Number of series	1	14	1	1	1	26
Sizes of samples	186	6-167	23	9	23	..
Stature	162.9	156.8-164.4	169.5	167.0	169.2	167.5-174.7
Head length	186.9	185.2-195.6	190.8	187.2	192.3	186.4-199.1
Head breadth	149.5	138.5-149.7	....	153.6	149.0	147.0-160.9
Bizygomatic diameter	141.8	135.9-143.9	....	139.6	141.8	141.3-148.4
Nose breadth	40.2	40.2-44.6	44.0	42.5	44.6	40.1-45.5
Total face height	122.1	121.6-131.1	136.0	115.2	125.3	121.5-131.1
Nose height	55.4	52.0-61.2	57.8	....	59.3	52.8-61.6
Cephalic index	80.1	71.3-80.9	....	82.1	77.5	74.3-86.5
Cephalo-facial index	94.7	92.6-100.0	....	91.0	....	91.3-99.1
Facial index	86.5	85.6-94.5	....	....	....	82.6-89.9
Nasal index	72.7	68.3-84.7	76.0	....	....	69.9-82.7

as a whole. The accompanying photographs of Yap males from my own series are shown in figures 3, 4 and 5. The "generalized" type, without pronounced Negroid or Mongoloid specializations, is probably common throughout Trans-Micronesia.

The hair form in the Trans-Micronesians is usually helical, with smaller helical diameters toward the west. In less precise terms, the hair looks wavy in the eastern islands, and becomes curly in the west. Occasional individuals seem to have "frizzly" hair in the western islands, but even here, the helical form is still apparent, in my experience.

The hair color is generally dark brown with a slight reddish tinge. The eyes are a medium to dark brown, and the skin usually a light brown.

The malars are often prominent, but without much overlying fat. Their lateral jut, together with the deep, broad mandible, result typically in a pentagonal face. Subcutaneous fat is likewise only moderately thick in the eyelids. Traces of many kinds of eyefolds occur, but seldom the puffy Mongoloid internal epicanthus, with a smooth curvature medially and a hidden caruncula. The axes of the palpebral openings are usually slightly slanted, and the margins are biconvex.

The nose form is highly variable, but usually the nostrils are visible both anteriorly and laterally. The sub-nasion profile of the nasal root is usually depressed. Glabella is commonly prominent. The browridges are usually moderate in size.

Since the boundaries of Micronesia and the neighboring parts of Oceania were invented by geographers and not by physical anthropologists, the limits of physical types and geographic frontiers do not always correspond. For example, Shapiro ('33) found that the Polynesian-speakers of Ontong Java, in Melanesia, resembled Micronesians from the Western Carolines. He attributed this resemblance to hybridization with Micronesians.

TABLE 2
Means of Micronesian male measurements (west to east). (Names of high islands in *italics*)

ORIGIN	NO.	STATURE	CHEST GIRTH	WAIST GIRTH	HEAD L.	HEAD BW.	CERVL. INDEX	FACE HT.	FACE BR.	EARIAL. INDEX	NOSE HT.	NOSE BR.	NASAL INDEX
Chamorroes													
<i>Sapan</i>	186	162.9	879.3	186.9	149.5		80.1	122.1	141.8	86.3	55.4	40.2	72.8
Trans Micronesians													
Pohni	16	156.8	840.0	....	191.1	139.1	72.8	121.6	136.3	85.6	52.0	44.0	84.7
Sonsorol	11	164.1	886.2	....	194.5	138.5	71.3	130.8	138.3	94.5	39.5	43.2	73.1
<i>Palau</i>	134	160.9	860.8	....	185.2	149.7	80.9	123.7	141.2	87.6	55.0	41.6	76.2
<i>Yap</i>													
(Hasebe)	46	160.5	867.1	....	189.0	146.4	77.5	123.0	143.9	85.6	56.2	42.1	75.2
<i>Yap</i>													
(Hunt)	347	160.3	....	....	188.5	150.1	79.6	117.2	145.0	81.0	54.8	41.7	76.2
Western													
Carolinee ¹	41	163.8	886.6	....	194.3	143.1	73.7	125.1	140.6	89.1	55.5	42.3	76.5
<i>Truk</i>	164	161.6	840.3	733.2	189.7	139.1	73.4	123.6	136.6	90.6	55.7	43.1	77.7
Mortlock	59	163.5	864.4	733.1	191.4	140.8	73.6	124.2	138.6	89.7	55.4	43.9	79.5
Ngatik	13	163.8	886.1	757.2	194.6	143.3	73.7	130.0	138.6	93.5	59.9	40.8	68.3
<i>Ponape</i>	150	162.1	853.0	734.9	192.8	142.1	73.7	126.7	139.2	93.3	59.5	42.4	71.6
Mokil	22	163.2	876.7	733.1	194.5	145.0	74.7	125.6	139.5	90.1	57.1	42.1	73.9
Pingelap	27	160.8	894.2	774.0	195.6	148.9	76.2	132.2	141.7	93.3	61.2	43.8	71.8
<i>Kusaie</i>	72	160.3	855.8	743.1	188.3	147.2	78.3	123.2	136.4	90.5	57.0	41.9	73.9
Ralik	165	162.1	870.8	760.7	188.4	145.2	77.2	127.7	138.9	92.0	59.1	43.8	74.4
Ratak	71	161.6	862.3	748.5	188.9	142.7	75.6	127.0	138.2	91.9	58.1	43.6	75.4
Polynesian-speakers													
Kapingamarangi													
(Seliagin-haufen)	33	171.1	....	....	195.4	153.3	78.5	117.3	144.6	81.1	52.6	45.0	85.7
(Hasebe)	23	169.2	920.6	794.8	192.3	149.0	77.5	125.3	141.8	88.5	59.3	44.6	75.5
Nukuoro													
(Hasebe)	7	171.0	922.4	799.7	190.5	153.0	80.4	124.8	143.7	93.8	62.8	42.0	67.0

¹ These islands extend from Ulithi to the Hall Islands north of Truk.

Similarly, the Polynesian-speakers of Kapingamarangi and Nukuoro, in the eastern Carolines, are metrically quite within the Polynesian range. Schlaginhaufen ('29), Hasebe ('38), and recently, Sir Peter Buck (unpublished) have worked on Kapingamarangi; and only Hasebe ('38) on Nukuoro. Their findings are in substantial agreement. It is to be hoped that Buck's series will be published soon.

It is noteworthy, too, that not all the easternmost Trans-Micronesians tend toward Polynesian dimensions. The Marshallese, to the northeast, surprised Hasebe in that he found virtually no tall, massive, metrically Polynesian types among them.

Within the Trans-Micronesian area, the differentiation of local groups is quite significant; yet sometimes metrically similar populations are separated by thousands of miles. The evidence from Hasebe ('38) will make these regional differences more clear. Except for my own series on Yap and that of Schlaginhaufen for Kapingamarangi, which are offered merely for comparison, all the data are the fruits of Hasebe's investigations. Table 2 includes all of Hasebe's averages except for a few which are seldom used by most anthropometrists: torso length from the suprasternal notch to the pubic region, overall head height, and certain related indices.

The table shows that the statural means for Trans-Micronesians vary around 160 cm, but the tallest groups form a band of atolls in the western and central Carolines, from Sonsorol to Mokil. As was mentioned earlier, the Gilbert Islanders are exceptional in being within the Polynesian range around 170 cm.

Chest girth is generally greatest, like stature, in this same band of atolls, and so is waist girth, wherever Hasebe performed this measurement.

The greater stature and bulk of these atoll groups might reflect their more active boating and fishing, except that it does not occur in the Marshalls, which are also low islands.

Another possibility, to be explored later, is that these physical characteristics may have resulted from Polynesian admixture.

Absolute head length is least in the east and west, and greatest in the center. Absolute head breadth is mainly least in the center, and greatest in the east and west. The cephalic index is on the border of brachycephaly in Palau (and among the Chamorros), and decreases toward the center of Micronesia. It increases again in the east and south.

The total face heights show that the west, Kusaie and Truk have the shortest faces. The east, center, and Sonsorol have the longest faces. Absolute face breadth is greatest in the west and least in the center and east, except for narrow faces in the southwest at Tobi. The facial index is low in the west and higher in the east, except for a high value at Tobi.

Short noses are generally western and long noses eastern. Narrow noses are the same, except for an extreme breadth at Tobi. The nasal index is highest in the east and west, except for a high value at Truk, and lowest in the center.

Although the foregoing summary is based on adult male averages, the female series could have been used equally well. They are not available for as many localities as the male data, but show similar regional differences in stature, chest and waist girths, and facial dimensions.

In addition to his metrical averages, Hasebe made an analysis of metrical types in both sexes within each local Micronesian sample. His method differs from that of Dixon ('23) in that Hasebe does not assume that his metrical types should apply to the whole human species. Instead, these types resemble those of Oceanic natives whose ancestors may have been related to the prehistoric immigrants into Micronesia.

In constructing his metrical types, Hasebe used combinations of stature, cephalic index, facial index and nasal index. He used standard intervals for all indices, but his statural

classes are less than those in common use by 3 cm. He divided stature as follows:

	MALE		FEMALE	
Short	X	-156.9	X	-146.9
Medium	157.0-166.9		147.0-156.9	
Tall	167.0-	X	157.0-	X

Of the 108 possible combinations of these data, Hasebe made 9 by combining them, and considered 4 out of the 9 as "polar" types. The ensuing discussion will deal only with the 4 polar types. The terminology used here differs from that of Hasebe, since each of his terms refers to the Micronesian island where the type is most prevalent. The present terminology, used in quotation marks, seems more manageable in that it has numerous precedents in the somatological literature.

The first, or Tokobe (Tobi) type will be referred to as "metrically Negroid." This metrical class has short to medium stature, dolichocephaly, and the facial index is eury- or mesoprosopic. The nose is chamae- or mesorrhine. It occurs especially in the eastern Marshalls (Ratak) and the western high islands of Yap and Palau. It is very conspicuous in the people of Tobi, a tiny island at the extreme southwest near New Guinea. Hasebe attributes its prevalence at Tobi to admixture with New Guinea Negroids. This type is therefore mainly northeastern and southwestern, and is rare in the more central islands extending from Ngatik in the central Carolines to the western Marshalls (Ralik).

The second, or Ponape type, is "metrically generalized." The stature is variable, the head dolichocephalic, the face leptoprosopic or hyperleptoprosopic, and the nose mesorrhine or leptorrhine. This combination occurs in 70% of Ponapeans, and in over 50% of the series measured on Truk, in the Mortlocks, Ngatik, Sonsorol and Mokil. It is therefore a central type, with an extension far to the southwest at Sonsorol.

The third, or Nukuoro type is, "metrically Polynesian." Its features include tall stature, meso- or brachycephaly, medium to very long facial index, mesorrhiny or leptorrhiny. This type occurs commonly among Polynesian speakers on Nukuoro and Kapingamarangi, and in a few Saipan Chamorros. It is notably rare among the Trans-Micronesians. Its association with Polynesian speech and culture within Micronesia seems clear.

The 4th, or Palau type, is "metrically Mongoloid." The stature is short to medium. The head is meso- or brachycephalic, and the facial and nasal indices variable except for an absence of hyperleptoprosopic faces. This type exceeds 50% of the series from Yap, Palau, and among the Saipan Chamorros, in the west. It recurs in isolation in more than half of the series from Kusaie, in the east. Brachycephals of this type are absent in Micronesia east of Truk except at Kusaie. This metrical class is therefore essentially western, with Kusaie as an easterly exception to the rule.

Hasebe's morphological observations provide further evidence on regional physical differences within Micronesia. He noted that the internal epicanthus is commonest in Palauans, Chamorros, Marshallese, and among the Polynesian speakers on Kapingamarangi. This eyefold corresponds to areas of a somewhat higher cephalic index than is usual in Micronesia, but not outside the range of mesocephaly. It is associated with "metrically Mongoloid" concentrations in Palau and among the Chamorros, but not further east in Kapingamarangi and the Marshalls. Furthermore, the somewhat "metrically Mongoloid" enclave on Kusaie does not show an excess of internal eyefolds.

As mentioned earlier, the hair is most strongly curved in the west: particularly Palau, Yap, and the western Caroline atolls. The hair seems to straighten toward the east, along with a decrease in "metrically Negroid" individuals. It does not become more curly again, however, in the more "metrically Negroid" inhabitants of the eastern Marshalls.

If the metrical and morphological findings are recast in geographic terms, they indicate that the western high islands of Yap and Palau are relatively Negroid and Mongoloid. Tobi, at the extreme southwest, is mainly Negroid.

The other islands from Sonsorol eastward are more long-headed, with an eastward loss of both Negroid and Mongoloid specializations. The people lack the internal eyefolds which are concentrated elsewhere, and an eastward straightening of the hair takes place. Two exceptions to these trends appear, however. One is the isolated increase of "metrical Mongoloids" on Kusaie, without an excess of internal eyefolds. The other exception is the recurrence of metrical "Negroids" in the eastern Marshalls, along with an excess of these eyefolds and relatively straight hair.

It is clear that neither eyefolds nor hair curvatures show perfect agreement with the metrical types. Such discrepancies are so common in racial somatology that historical inferences based on measurements or observations alone are totally inadequate, as Hooton ('46) has often pointed out.

HASEBE'S THEORY OF MICRONESIAN RACIAL HISTORY

Largely on the basis of his own anthropometry, and without reference to the distribution of blood groups, Hasebe has formulated a theory of Micronesian racial history. His underlying assumption is that oceanic currents have directed most of the major migrations into the area.

Two major currents flow through Micronesia. The first is the Equatorial Counter Current. South of the islands, just above the equator, it moves from west to east. Part of it veers northward in the center of Micronesia, past the Mortlocks and Truk, and turns westward past the Western Caroline atolls. The second major flow is the North Equatorial Current, which moves westward from the area of the Marshall and Gilbert Islands. It meets the arm of the Counter Current in the Western Carolines. After this union, the water approaches the Philippines, where it turns northeastward as the Japan Current.

Hasebe ('38) maintains that man first entered Micronesia along the Equatorial Counter Current. From New Guinea, the migrants moved from Tobi to the Mortlocks, Truk, and finally westward into Yap and its neighborhood. These first arrivals were Negroids of rather short stature, with small heads and strongly curved hair. Many students of Oceanic racial history would consider them as fundamentally Negritoid.

The second wave of migrants were of medium stature, with long heads and faces. They may have come from northern New Guinea to the outliers in Melanesia where Polynesian is now spoken, through the Bismareks and Solomons, and thence into Micronesia. They occupied all of Micronesia and mingled with the first wave. They resembled most closely the modern natives of Ponape, the Mortlocks, Truk, and the Western Caroline atolls. This physical type is called "generalized" in the present context.

Certain newer studies of Australian and Melanesian racial history (Howells, '43; Birdsell, '47; and Avias, '49) have considerably refined the typology of Oceanic races. It is possible that Hasebe's "generalized" metrical class may be too crude an instrument for adequate historical analysis, even of Micronesia alone. Sporadic cases in my Yap series resemble most of the extremes of Oceanic physical variation. The way should surely be left open for a more refined study of physical types and blood groups among the Micronesians, with an eye to a better integration of the data from Oceania as a whole.

According to Hasebe, the third wave of immigrants into Micronesia was composed of Polynesians. They were tall, with large heads and faces. They may have come along the Equatorial Counter Current, but hardly reached the Marshalls at all, contrary to Hasebe's original expectations. He does not mention the probable westward migrations out of Polynesia proper which settled the Ellice Islands, and apparently considers the peoples of Kapingamarangi and Nu-

kuoro as remnants left behind in the eastward voyages of the original Polynesians.

After the Polynesians came the Indonesian Mongoloids, with shorter stature and brachycephaly. They occupied not only Palau, Yap and the Marianas, but some followed the Equatorial Counter Current to Kusaie and the western Marshalls. Their influence was slight elsewhere, however.

MICRONESIAN BLOOD GROUPS

The distribution of the ABO blood groups in Micronesia has been worked out by Japanese investigators, but more complete serological studies have not yet been done. The Japanese students, however, have used their data more for characterizations such as "Pacific American" than for more comparative studies within Micronesia. Japanese sources include Takasaki (cited by Furuhata, '27, and by Boyd, '39), Mitsaitsu (also cited by Boyd, '39), and Kuwahara ('42). The data are presented as a graph with three coordinate axes which permits an objective test of serological resemblances. Each axis represents the gene frequencies of one of the three blood group genes: p (gene A), q (gene B) and r (gene O). This method was devised by Streng ('30), and is quite satisfactory except that it cannot represent the subgroups of p (A). Since Micronesian data on these subgroups have not yet been gathered, they will not be considered further.

The three gene frequencies for any given series of blood group samples are represented by a point on the graph, referred to here as a "locus." So long as the computed gene frequencies add up approximately to unity, no problem arises in plotting loci. Occasionally they do not, for reasons having to do with statistical probability or perhaps faulty technique. A series done by Mitsaitsu on Trans-Micronesian colonists living on Saipan could not be plotted, for example. Fortunately, Takasaki also studied a sample of these colonists, and his data are included on the graph along with the remaining Micronesian loci.

The total number of loci for any given geographic area can be enclosed by a line. Such an enclosed section of the graph can be called a "field."

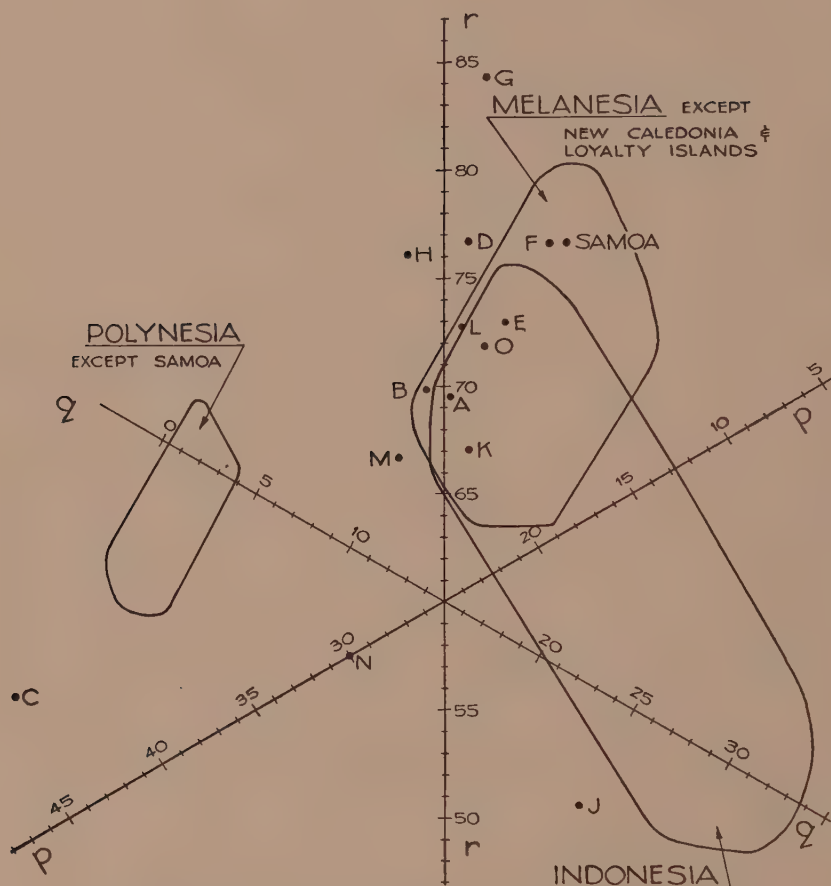
Avias ('49) has recently delineated the major serological fields of the world as a basis for studying the blood groups of Oceania as a whole. His fields for Polynesia (except for Samoa, which is plotted separately), Melanesia (except for New Caledonia and the Loyalty Islands) and Indonesia are reproduced in figure 2. By referring to both the loci and the fields at one time, the serological affiliations of local Micronesian populations become apparent.

The chart shows that most Micronesian loci fall within the overlapping parts of the Melanesian and Indonesian fields. The remaining loci show a great deal of scatter. Since Micronesian populations are often small and endogamous, local insular peculiarities in blood group gene frequencies may have arisen in their evolutionary history. Such endemism is common enough in other organisms on small islands.

In the upper right direction are Yap, Palau and the Marshalls. In other words, their values of both p and q are nearly equal, and r is relatively high. Since these three areas are somewhat Negroid in morphology, it is possible that their similarities in blood groups are related to their morphological similarities.

Most of the other loci lie toward the upper center of the graph. The tendency of these loci to lie on the fringe or outside of the Indonesian and Melanesian fields suggest the same conclusion as the metric data: that the central Micronesians have less in common with Oceanic Negroids and Mongoloids than the inhabitants of the periphery. These trends may also reflect Polynesian admixture.

Certain discrepancies occur, however, in the central high islands, as well as in the Marianas. For example, the metrically Mongoloid Chamorros resemble the central Micronesians in their blood group gene frequencies. Truk is high in both the p and q genes, although not strongly Mongoloid metrically. The Kusaiens have high p and moderate q , al-



TRIANGULAR GRAPH OF OCEANIC
 ABO BLOOD GROUP GENE FREQUENCIES
 ADAPTED FROM AVIAS, 1949 & OTHER SOURCES
 INVESTIGATORS: T-TAKASAKI, M-MITSATSU, K-KUWAHARA
 A SAIPAN CHAMORRO - M H WOLEAI - T
 B SAIPAN CHAMORRO - T J TRUK - T
 C SONSOROL - T K MORTLOCKS - T
 D PALAU - T L PONAPE - T
 E PALAU - K M MOKIL & PINGELAP - T
 F YAP - T N KUSAIE - T
 G SAIPAN TRANS- O MARSHALLS - T
 MICRONESIANS - T

Fig. 2 Blood frequencies.

though Kusaie is metrically more Mongoloid than other eastern Micronesian islands.

The Chamorro and Kusaie discrepancies can be resolved if certain immigrants into Micronesia were metrically Mongoloid, but not high in *q*. Such groups still exist in modern Indonesia. The peculiar distribution of blood groups in Truk, however, is still unexplained on this basis.

Geographically, Truk is an obvious center for the dispersion of populations, as Hasebe has pointed out, since Truk is the first large island group astride the Equatorial Counter Current. Possibly it has been occupied by a recent wave of immigration, high in *q* but not strongly Mongoloid.

From an evolutionary standpoint, three loci on this chart are of particular interest. They all represent groups whose origin is the atolls of the Western Carolines: Sonsorol, Woleai, and the Trans-Micronesian colonists who live on Saipan. Although they are probably closely related historically, they are remarkably unlike serologically. The migration of small groups, inbreeding, and possibly random gene loss may have given rise to these differences.

POLYNESIAN MIGRATIONS THROUGH MICRONESIA

Most authorities believe that at least some of the Polynesians crossed Micronesia on their way from Indonesia eastward to their present homes. In view of the great interest in Polynesian history among anthropologists, it is well to recapitulate some of the Micronesian evidence on this subject.

From Sonsorol eastward to Mokil, the low islanders are somewhat tall and burly, with high *p* and low *q* blood groups. They are dolichocephalic, with relatively few Negroid and Mongoloid specializations. These features suggest that these islands could have been a Polynesian migration route at a time when long-headed Polynesians, low in the *q* gene, were crossing Micronesia.

Shapiro ('43) believes that the earlier immigrants into Polynesia differed from the later ones mainly in being more dolichocephalic. Possibly some of the later comers had more

of the q gene than their predecessors, thereby accounting for the higher concentration of q in Samoa (Shapiro, '40).

Since the later comers seem to have introduced elements of a more elaborate culture into Polynesia, it is tempting to suppose that they derived these elements from peoples other than atoll dwellers. If these later migrants encountered large, culturally advanced populations en route, they may have learned such elements then. Possible sites for such encounters might be Indonesia, Palau, Yap, or even Kusaie. Any concomitant interbreeding, especially in the west, could have introduced more brachycephaly or the q gene, or both, into the migrant groups. At the same time, a few Polynesian genes might not radically alter the physical features of any large population already present on a high island.

The foregoing speculation is based on the assumption that the Polynesians may have crossed Micronesia after some of the Micronesians had already become partly brachycephalic through earlier Mongoloid admixture.

At some more recent date, Polynesians seem to have infiltrated back towards the west again, into the Ellice Islands and parts of Melanesia. Such movements were still going on in the 19th century, when Polynesians from Rotuma, south of the Ellice group, invaded and settled on Kusaie. Some of the present Kusaieans, according to Hasebe ('38) have partially Polynesian ancestry for this reason.

The Polynesian speakers on Kapingamarangi, at least, use a dialect which may not be secondarily derived from Polynesia proper (Murdock, '48b). It is tempting to suppose that these islanders are survivors of an early Polynesian migration eastward from Asia. Dr. Kenneth P. Emory, however, has told me that he believes Kapingamarangi was settled from the Ellice Islands. The physical data so far cannot decide this question.

The foregoing evidence shows that a beginning has at least been made in Micronesian somatology. The measurements, observations, and blood group percentages do not make a perfectly coherent picture, however. Further work on Micro-

nesian history should be at least as much the concern of the archaeologist, linguist and ethnologist as of the physical anthropologist. No historical statement in this paper stands on firm ground yet, and cultural evidence is a necessary part of the reconstruction.

POSTWAR RESEARCH IN MICRONESIAN
PHYSICAL ANTHROPOLOGY

Although a racial description of the Micronesians is now possible in broad outlines, much additional research needs to be done. The publication of anthropological studies of these islanders can be expected at an increasing rate in coming years.

In 1947 and 1948, the Navy Department and the Pacific Science Board of the National Research Council arranged for several American and Australian research institutions to send anthropologists into Micronesia. This ambitious project was called the "Coordinated Investigation of Micronesian Anthropology" or CIMA. In two recent articles, Murdock ('48a and '48b) has described some of its aims and achievements.

As part of the whole CIMA program, studies of human biology were made on several of the islands. Among these projects was the psychiatric and nutritional survey done by Dr. Alice Joseph and Dr. Veronica Murray on Saipan.

Anthropometric series were measured in a number of localities. Sir Peter Buck and Dr. Kenneth P. Emory worked on Kapingamarangi, Dr. W. W. Greulich on Guam, Dr. William Lessa on Ulithi, and Mr. Rupert Murrill on Ponape. My own series was measured on Yap. Some of these studies included somatotype photographs, and were oriented toward constitutional as well as racial problems.

Constitutional and ecological studies are unusually feasible in Micronesia. Japanese vital statistics were kept with great accuracy in some localities, so that the year of birth can be discovered for many natives. It is possible that baptismal records for infants may also be available.

The consequences of such information are far-reaching. Cross-sectional studies of growth and aging are possible, and Dr. Greulich's studies on Guam are a promising beginning in this field. Possibly longitudinal studies could be initiated in some places. Significant problems such as maturation rates in populations, and differences in growth among various physical types, become possible, as well as demographic questions such as the relationship of body build and fertility, aging, diseases and longevity.

An example of such research is that of Murrill ('49). He determined the blood pressure on a series of natives of Ponape, and investigated the effects of tropical residence and disease on aging in the circulatory system.

Constitutional and criminal anthropology in the United States is often complicated by the racial and cultural diversity of the populations under study. The Micronesians in any given locality are much more uniform in these respects, and offer certain advantages to the physical anthropologist for this reason, to say nothing of the cultural anthropologist.

Serological research, too, should be resumed in Micronesia, using tests for as many as possible of the subgroups, types and factors. The time is ripe for more, not less, work on physical anthropology in these islands.

SUMMARY

The literature on Micronesian somatology and serology, particularly the anthropometric survey of Hasebe ('38), shows that the Micronesians are physically and genetically diverse. The Chamorros of the Marianas are metrically the most Mongoloid group, although they do not have the high percentage of gene q (the B agglutinin) which usually characterizes Mongoloids nearer Asia.

The western islanders of Yap and Palau are both more Negroid and more Mongoloid than other natives of the Caroline Islands. Tobi, to the extreme southwest near New Guinea, is the most Negroid island in Micronesia.

From Sonsorol in the southwest through the atolls of the Western Carolines is a group lacking strongly Negroid and Mongoloid features, with slightly greater stature and body bulk than other Micronesians proper. Their blood groups are low in gene q (the B agglutinin). These features suggest a slight Polynesian admixture. This chain of islands may have been a Polynesian migration route.

Kusaie, to the east, is metrically a more Mongoloid enclave. The eastern Marshalls seem to be more Negroid metrically, and perhaps serologically.

Probable intergrades of Micronesian and Polynesian physical types occur in the Gilbert Islands. The Ellice Islands, and the southern Caroline atolls of Nukuoro and Kapingamarangi, are still inhabited by metrically and culturally Polynesian groups.

The sequence of physical types which entered Micronesia is still obscure. Hasebe suggests that it was first Negroid, then a small, generalized type, then Polynesian, and finally Mongoloid. In my opinion, the Polynesian may have been the most recent immigration wave, at least in some parts of Micronesia.

The peoples of Micronesia are suitable for many kinds of somatological study: growth, constitution and ecology. More work is needed, too, in serology.

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Without the initiative of Mr. Nathaniel R. Kidder and Mr. William D. Stevens, and the help of Drs. Kotondo Hasebe

and John Pelzel, the important Hasebe manuscript would not have been translated. Dr. Hasebe's work was the main stimulus for this paper. He has set the other students of Micronesia a brilliant example.

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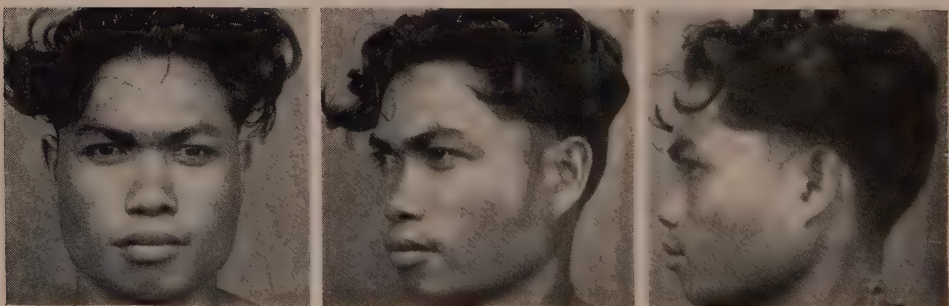
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3



4



5

EXPLANATION OF FIGURES

Three morphological variants from Yap

- 3 "Oceanic Negroid"
- 4 "Generalized"
- 5 "Mongoloid"

VITAL STATISTICS OF PONAPE ISLAND, EASTERN CAROLINES

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ONE FIGURE

In the summer of 1947, as a member of the project entitled the "Co-ordinated Investigation of Micronesian Anthropology" (C.I.M.A.), I was delegated to study the physical characteristics of the natives of Ponape Island. At the same time I was able to obtain information on vital statistics.

Ponape is a high basalt island in the Eastern Carolines, approximately 380 miles east of Truk, 900 miles southeast of Guam, 2680 miles from Honolulu and 2360 miles from Manila. The island is about 130-145 square miles in size, with mountains in the interior rising to 2500 feet. Between the coast line and the foot of the mountains the land is mostly flat, and it is here that the natives live. It is divided into 5 Districts — Sokas, Net, U, Matolenim, and Kitti. The Districts are divided into Sections and these into farmsteads. The climate shows an annual average temperature of 80°F., humidity of 86%, and rain-fall around 180 inches.

Ponape has had many contacts with foreigners. During the years 1826 to 1886 American whaling ships visited the island, especially in the 1850's. By the 1870's there were on Ponape trading stations of three German firms, which were combined in 1887 to form the Jaluit Company. From 1886 to 1899 the island was held by the Spanish who brought in some Philippine soldiers. Between 1899 and 1914 it was a German possession. The Germans are said to have introduced a few New Guinea workmen. By 1893 two Japanese firms were trading on Ponape, and in 1906 these firms combined to form Nambo, or

the South Seas Trading Company. In 1910 the German governor was killed in the "Sokas rebellion," due to which the Sokas inhabitants were deported to Palau in the Western Carolines. In 1912, after a typhoon had caused severe damage to several islands in the Carolines, about 1250 "out-islanders" were brought to Ponape and settled in Sokas. This was the last native immigration to Ponape of any considerable size. During the Spanish and German periods the number of whites on the island was continually small. From 1914 to 1945 Ponape belonged to the Japanese, who heavily colonized the island. They returned to Ponape from Palau the remaining deported

TABLE 1
Official censuses of total native population

YEAR	NO.	ADMINISTRATIVE POWER
1920	4165	Japanese
1930	5320	Japanese
1940	5866	Japanese
1947	5855	American

Sokas inhabitants. In 1945 the Japanese and Korean population of 14,066 (Army, Navy and Civilian) was removed by the Americans, who now hold the island under a trusteeship.

As it to be expected from the above short history the population of Ponape is today a varied one. We may, however, conveniently divide the native population into two main types; (1) "pure" Ponapeans — that is to say, those whose ancestry shows no mixture with whites; (2) "mixed": these can be sub-divided into: *a.* Ponapean natives who mixed with whites, such as Americans, English, French, Germans, and Portuguese; *b.* Ponapean natives who mixed with "out-islanders," natives from surrounding islands; *c.* Ponapean natives who mixed with the Japanese; *d.* various combinations of *a*, *b*, and *c*.

Since my main concern was to make an anthropometric study of the "pure" Ponapean type, most of the women used in the population sample fall into this category.

POPULATION

Most of the Japanese-collected vital statistics such as birth, death, and infant mortality rates, age and sex composition, are given under the heading of the Ponape Branch Bureau, which was the Japanese Administrative District for the Eastern Carolines. This Branch Bureau included besides Ponape such islands as Greenwich (Kapingamarangi), Mokil, Ngatik, Kusaie, etc., and therefore one cannot apply the above vital statistics to Ponape alone.

TABLE 2

Average number of live births in first 5 years of marriage, by age groups

PRESENT AGE	NO.	AGE IN YEARS AT MARRIAGE	AVERAGE NO. OF LIVE BIRTHS IN FIRST 5 YRS. OF MARRIAGE	APPROXIMATE YEAR SPAN
30-39	54	17.5	1.5	1930-39
20-29 ¹	44	17.0	1.2	1940-47

¹ In this group all women 20-22 years of age had been married 5 years or more.

For this reason, although not knowing the total number of native births and deaths on Ponape during 1946-47, due to faulty or non-registration of same, I have had to rely mostly on the 1947 total native population census, and whatever additional information I could obtain from the natives themselves.

Table 1 shows the official censuses taken of the total native population. Only those censuses considered reliable have been used, due consideration being given to the equating of immigration and emigration. Between the years 1920 and 1940 there was a total gain of 40.8%. However, between 1920 and 1930 the gain was 27.7%, between 1930 and 1940 only 10.3%, and between 1940 and 1947 there was a decrease in the population.

There is an indication that this recent decrease is due to a decrease in the birth rate. Information was obtained from a sample of 162 women, covering the 5 Districts of Ponape. That this sample was representative is shown by the fact that there were 58 children ages 0-4 years for 128 women ages 15-44, from the sample of 162 women, which gives for 1000 of these women 453.1 children. The 1947 census (table 4) shows 625 children ages 0-4 years for 1354 women ages 15-44, giving for 1000 of these women 461.6 children.

The results of the younger age groups, in the sample of 162 women, are given in table 2. This indicates that the younger women are having fewer children in the first 5 years of married life, especially the youngest, since out of the women of ages

TABLE 3
Age-specific birth rates

PERIOD	TOTAL ¹	AGE OF MOTHER						
		20- 24 ²	25- 29 ²	30- 34 ²	35- 39 ²	40- 44 ²	45- 49 ²	50 + ²
June 1946 - June 1947	76.4	111.1	166.7	85.7	47.6			

¹ Births per 1000 females 15-54 years of age.

² Births per 1000 females of that age group.

20-29 there were 18, aged 20-25, who had a total of 11 children in the first 5 years of marriage, or an average of only 0.6 children.

This can also be shown in another way. From the sample of 162 women the age-specific birth rates shown in table 3 were obtained. These rates must be used with caution since they are based only on a sample of the population. However, it can be seen that the age-specific birth rate for the 25-29 year age group is higher than that of the 20-24 year age group, even though the mean age at marriage for 162 women was 17.6 years, and although from a sub-sample of 122 women 20 years of age and over only 2, or 1.6%, were unmarried.

One explanation was given me by the natives themselves for the small number of children found in the 20-25 year age

group (of the 20-29 year age group, table 2), and for the small number of one year old children in the total native population census of 1947 (table 4) — namely, that during the latter part of the recent World War many women were forced by the Japanese into making rope from hibiscus, which necessitated standing in water often for hours on end. Many of these women during this period were said to have had miscarriages.

TABLE 4
1947 Ponape census. Total native population

AGE GROUP	MALE	FEMALE	TOTAL
Under 1 yr.	90	74	164
1 yr.	45	25	70
<i>years</i>			
2	71	56	127
3	68	66	134
4	59	71	130
5-9	284	289	573
10-14	330	306	636
15-19	325	273	598
20-24	303	298	601
25-34	583	506	1089
35-44	338	277	615
45-54	256	238	494
55-64	214	163	377
65-74	112	74	186
75 and over	30	31	61
Totals	3108	2747	5855

Shapiro ('42) has said of Sundbärg's observations on population: "He was the first to notice that about 50% of the total of most populations fall within the 15-49 year age class, an age division responsible for practically all of the reproduction of a population, and that the proportion of the total included in the prereproductive, or 0-14 year group, fluctuated inversely with the percentage in the post-reproductive group comprising those 50 years and over in age. Furthermore, Sundbärg reported that the reproductive vigor of a population was correlated with the proportion of the pre-reproductive

group to the total." Sundbärg's terms for the various proportions in a population, quoted by Pearl ('40), are shown in the following tabulation.

TERMS	PRE-REPRODUCTIVE GROUP 0-14 YRS.	REPRODUCTIVE GROUP 15-49 YRS.	POST-REPRODUCTIVE GROUP 50 YRS. AND OVER
"Progressive"	40%	50%	10%
"Stagnant"	33%	50%	17%
"Regressive"	20%	50%	30%

Sundbärg's data also show that the pre-reproductive group varies in proportion to the total from 22.2% in Sweden to 42.7% in Brazil. The 1947 Ponape census given in table 4, shows that the number of individuals, both sexes, in the 0-14 year group is 1834 or 31.3% of the total population. Assuming that the 15-49 year group is approximately 54%, then we have 14.7% in the 50 year and over, or post-reproductive group. With 31.3% of its population in the pre-reproductive group, Ponape falls into Sundbärg's "stagnant" type of population, and midway between the extremes of Sweden and Brazil. In other words the Ponape population is in neither an increasing nor a decreasing phase of growth.

Figure 1 illustrates the 1947 population profile of Ponape. In making the calculations for the profile in the 10 year age groups half the number of males and females in the census are used to be consistent with the 5 year age groups. The profile summarizes the population picture of Ponape and by its very shape, with approximately parallel sides up to the 25-34 year age groups, presents a population probably on the way to a decline.

For those who might wish to study the Ponape population in the future table 5 provides a summary of the fertility of those women 45 years of age and over, namely those who have finished their reproductive period of life, taken from the sample of 162 women. This table shows an average per mother of 5.6 children born alive, with approximately an average of 4 children surviving. Of the 57 children who died, 35 were one

year or less in age, or 61.4%. Of these 35 children, 24 were males and 11 females, indicating that infant mortality was high, especially among males. Finally, the average number of miscarriages was 0.6, but of the 32 women the miscarriages occurred in 10 women, of which one woman had 6 miscarriages. Only one stillbirth was recorded.

Concerning the problem of population throughout the Micronesian area formerly under the Japanese Mandate most of the available Japanese vital statistics are confusing. It is

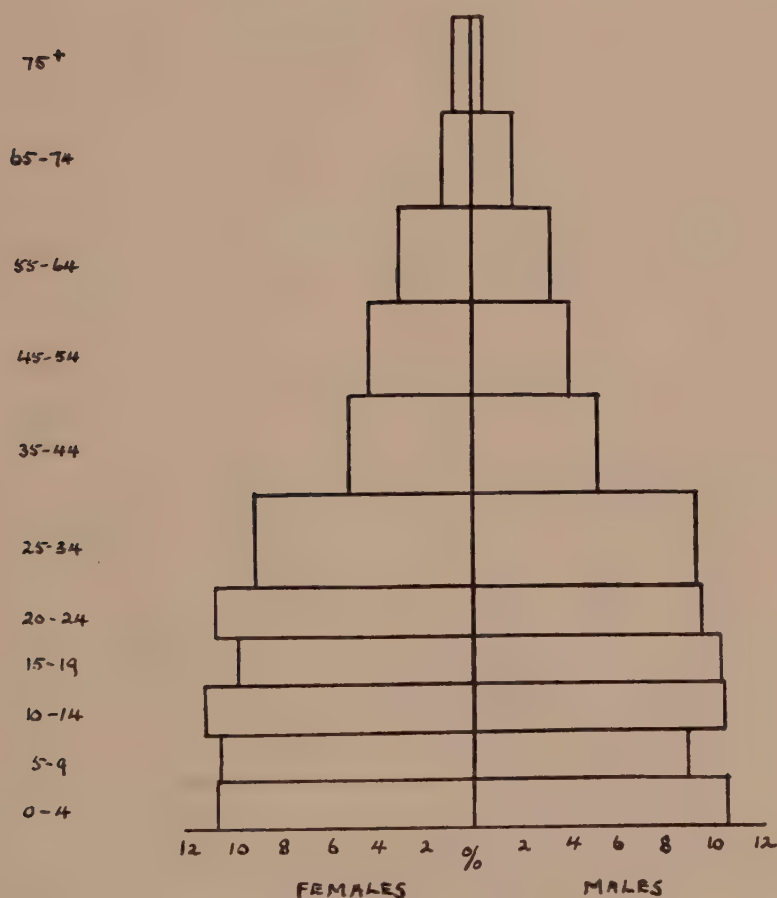


Fig. 1 Population profile, Ponape, 1947. Scale of age at left.

true, however, that under the Japanese the native (kanaka) population increased for the whole area. Between 1921 and 1938 the increase was about 7%. Undoubtedly during this period general medical and sanitary practices were considerably improved for the natives. During the same period the Mandated area became progressively more isolated as the Japanese did not desire any nationals except their own in this area. Inter-island migrations of natives occurred to some extent but no large scale native migrations into or out of the area.

Hence, the following crude birth and death rates (per 1000 of the population) show the regional differences that existed throughout the Mandate. For the total Mandate the average

TABLE 5
Fertility of women 45 years of age and over

NO. OF WOMEN AGES 45-60	NO. OF LIVE BIRTHS		NO. OF SURVIVORS		NO. OF CHIL- DREN THAT DIED	NO. OF MIS- CARRIAGES	NO. OF STILL- BIRTHS
	Male	Female	Male	Female			
32	96	84	56	67	57	20	1
Average per woman	3.00	2.63	1.75	2.09	1.78	0.63	0.03

crude birth and death rates for 1923-32 were 23.9 and 23.5 respectively. By 1937 the rates had improved to 25.0 and 21.8. In 1937 the rates were for Yap, 12.4 and 32.8; for Palau 24.7 and 11.9; for Truk, 27.3 and 25.6; for Ponape, 25.4 and 15.0. In 1935 the rates for the Marshalls were 21.0 and 22.9. In other words the regional differences were considerable. In 1937 Palau and Ponape Districts showed an increasing population. Truk and the Marshalls (1935) indicated a stationary, and Yap a decreasing population.

Comparable birth rates in 1935 were for the United States 16.9 and for Japan 31.6. Comparable death rates in 1938 were for the United States 10.9 and for Japan 16.8. However, one should remember Thompson's admonition ('42) that "Care must be used, in making comparisons between countries where

the data are of unequal accuracy and also where the composition of the population shows considerable differences."

The age composition of a population is often cited as an index to possible future trends. Yanaihara ('40) gives the following approximate percentages for the age group under 15 years of age for 1935: 40% in Saipan, 34% in Palau, 24% in Yap, 38% (?) in Truk, 39% in Ponape, and 29% in the Marshalls. These figures would indicate that in 1935 the Districts (each composed of several islands) of Saipan, Palau, and Ponape were in an increasing phase of growth.

However, since 1935 there has been a World War, one effect of which (miscarriages) on the Ponape Island population has been mentioned. Also it has already been shown that Ponape Island itself in 1947 had only 31.3% of its population in the 0-14 year age group. Therefore, until such time as the United States makes available the age composition of the various islands within the Districts of the former Japanese Mandate, it would be wiser to suspend any predictions about future population trends in Micronesia other than that of Ponape.

SUMMARY

The native population profile shows a population in a stationary phase of growth, probably on the way to a decline. The available evidence indicates a decreasing birth rate especially in women 20-25 years of age, possibly due to an increased number of miscarriages occurring during the later years of the recent World War.

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PROBLEMS OF EMIGRATION.—To be of even temporary benefit in easing the pressure of population . . . emigration must be on a large scale, and usually the natural increase rate of the emigrant-sending country rises sufficiently to offset the effects of the emigration.

This is what appears to have happened in Italy and in various other European countries during their periods of mass emigration.

Between 1880 and 1913, Italy sent forth millions of emigrants, but if one will examine Italy's curve of population growth, he will not be able to discover any downward effects of emigration. In fact, Italy's curve seems to have risen more sharply during this period of heaviest emigration.—Guy Irving Burch. *Britain's Way Out*. Population Bull., vol. 5, no. 4, Oct. 1949, pp. 25–31.

DIFFICULTIES OF POSITIVE EUGENICS.—Why, it may be asked, should we not encourage the breeding of rare and desirable genes as we can discourage the breeding of rare and undesirable ones? The answer is that we do not know of a single rare gene in man whose frequency we should increase. I have no doubt that such exist. But our analysis of the genetic basis of human abilities is so utterly rudimentary that we know nothing of them. Their discovery will need a vast program of collaboration between geneticists, physiologists, and psychologists. Until even one such gene is known, it seems to me rather futile to talk about a program for positive eugenics.

I would, however, suggest that among the genes whose spread we would want to encourage are those for the non-development of teeth, particularly wisdom teeth. Our cerebral development has caused a good deal of overcrowding of our teeth. I hope also that we shall do something about our noses, which are one of our weak points. (I have a nasal infection at the moment. No other organ lets me down so frequently.) The nose has of course been squashed out of shape by the growth of the brain. In consequence, while a sneeze takes a straight path in a dog or a horse, it has to take a hair-pin bend in our own species. In a century or so we may know of detailed changes in our psychological make-up which are equally desirable.—J. S. B. Haldane. *Human Evolution: Past and Future*. Chapter 22 in G. L. Jepsen, E. Mayr and G. G. Simpson (editors), *Genetics, Paleontology and Evolution* (Princeton Univ. Press, 1949, xiv, 474 pp. \$6.00).

BIRTH ORDER AND BODY SIZE

II. NEONATAL AND CHILDHOOD MATERIALS

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The words "Birth order and body size" duplicate the title of a stimulating paper recently published in this Journal (Howells, '48). This is intentional—and for two reasons. First, Howells' broad development of the problem of "body size in its relation to birth order" merits continuing use as a "thought scaffold" within which to assemble data on various facets of the topic. Secondly, the research materials amassed by Howells on young adults, and by the present writer on children, yield reciprocal insights when examined and appraised together. In other words, the generalizations which the two analyses support are complementary, throwing different phases of the problem into relief, and provocative, indicating the need for more substantial information at particular periods in ontogeny.

PURPOSE

Howells described an original study and reviewed previous research on the relation between body size and birth order in early adulthood (specifically, in college men). He arrived at the following summary statement (p. 459):

"If birth order, taken alone, has any constant influence on adult body form, this has yet to be demonstrated. Bowles found indications that among Harvard brothers of a generation or so ago the younger brothers had a constant size advantage . . . when Wisconsin brothers were compared simply as series of "older" and "younger," no corroboration of Bowles' results was found . . . A more careful comparison, by actual pair differences according to birth orders, was no more revealing."

It is the purpose of the present paper to bring together, augment, and synthesize studies on the same problem made at earlier stages of the life cycle, i.e., in infancy and during childhood. These studies are conveniently treated under three captions: body size in first- and later-born infants; size in infancy from more than twofold grouping on birth order; and birth order and body size in childhood.

BODY SIZE IN FIRST- AND LATER-BORN INFANTS

Many more neonatal contributions are available for the dichotomous group of "first-born" and "later-born" (offspring from primiparous and multiparous labors) than for further refined subdivisions on order of birth. Further, a much larger number of anthropometric traits have been analyzed on this bipartite basis than using more numerous categories of ordinal position in the family. No less than 40 measures of body size and one measure of body shape (the cephalic index) have been investigated on infants separated into two classes, first-born and later-born.

The quantity of material for body weight at birth far exceeds that for any other age or measurement. In table 1 are listed means from 60 samples each of first-born and later-born infants. The total number of subjects utilized approximates 137,000.

Tables 1 and 2 are complementary, the latter affording descriptive data characterizing each of the studies included in the former. Both tables will be found largely self-explanatory. In table 1, there occur under "number of subjects" 6 instances where a number is enclosed in parentheses. Each number represents first- and later-born infants together, and implies that the investigator did not specify the size of either subgroup.

Turning to table 2, a few comments will be helpful with reference to the last column. Here, an attempt has been made to describe succinctly the criteria used by each author in sample selection. In some instances space limitations have made it necessary to register a criterion by one word, e.g.,

single, live, viable, normal, term. "Single" implies that infants from single pregnancies only were taken, all twin and other plural birth (multiple pregnancy) records being rejected. "Live" implies that no records for stillborn infants were accepted. "Viable" is used in the special sense of eliminating all records for infants dying within the first 10 days after birth (Benestad, '14) or including only cases surviving the hospitalization period and leaving the hospital in good condition (Hanley, '34). "Normal" refers to the physical condition of the infants and is synonymous with no observed pathology (abnormalities excluded; records marked positive for physical deformity, malfunction or diseased condition rejected; etc.). "Term" is used where an investigator states without explanation that only full-term infants were included or, conversely, that all premature infants were rejected. Whenever possible, the criterion or criteria of maturity employed has been indicated, e.g., birth weight over 2.5 kg; birth length 48 cm and up; period from first day of last menstruation to birth over 37 weeks.

On inspection of the last column in table 1 it will be seen that the direction of the listed differences is consistent throughout. From every one of the 60 studies, the mean weight for first-born infants is less than that for infants of higher birth orders. The amount by which the first-born are surpassed by the later-born varies between .04 kg and .43 kg. The best approximation of the true magnitude of the difference is .183 kg. This is the value obtained by pooling the data from the separate studies,¹ calculating composite means for 60,480 infants of primiparae and 73,650 infants of multiparae, and subtracting the second mean from the first.

Two substantial biologic generalizations may be drawn. First-born neonates typically are lighter than the aggregate of neonates of other birth orders. Quantitatively, the latter

¹ In rows 1, 27, 37, 39, 48 and 52 the number of subjects for each subgroup was taken as one-half the total sample. The data of rows 23 and 24 (which are included in row 51) and of rows 42, 50 and 57 (which are for paras 1 and 2 only) were omitted.

TABLE 1

Body weight at birth (kg) from sixty samples each for offspring of primiparae (first-born infants) and multiparae (later-born infants). All figures are for both sexes together

INVESTIGATION	NUMBER OF SUBJECTS		MEAN WEIGHT		LATER-BORN HEAVIER BY:
	First- born	Later- born	First- born	Later- born	
1. Frankenhäuser (1859)		(1,702)	3.36	3.50	.14
2. Gassner (1862)	44	110	3.23	3.33	.10
3. Haahe (1862)	47	53	3.20	3.25	.05
4. Duncan (1864)	1,011	1,042	3.25	3.30	.05
5. Hecker (1865)	1,610	2,839	3.18	3.34	.16
6. Frankenhäuser (1867)	783	705	3.15	3.28	.13
7. Schroeder (1869)	244	139	3.14	3.24	.10
8. Pfannkuch (1872)	257	346	3.12	3.25	.13
9. Sobbe (1872)	834	1,166	3.18	3.26	.08
10. Ingerslev (1875)	1,723	1,727	3.25	3.41	.16
11. Fasbender (1878)	291	339	3.20	3.37	.17
12. Budin and Ribemont (1879)	96	87	3.21	3.32	.11
13. Hofmeier (1879)	59	41	3.35	3.39	.04
14. Woinarski (1879)	80	91	3.18	3.42	.24
15. Kémárszky (1884)	1,405	1,981	3.18	3.33	.15
16. Stockton-Hough (1885)	423	288	3.19	3.47	.28
17. Issmer (1887)	3,801	3,809	3.19	3.33	.14
18. Keiller and Robertson (1890)	33	31	3.29	3.35	.06
19. Pinard (1898)	1,524	2,182	3.12	3.32	.20
20. Fourman (1901)	904	449	3.22	3.40	.18
21. Kinoshita (1901)	38	49	2.98	3.04	.06
22. Wilcke (1901)	943	910	3.25	3.45	.20
23. Riggs (1904)	196	168	3.00	3.13	.13
24. Riggs (1904)	370	227	3.22	3.48	.26
25. Landois (1905)	18	30	3.24	3.36	.12
26. Longridge (1905)	200	200	3.11	3.25	.14
27. Fuhrmann (1907)		(1,000)	3.12	3.55	.43
28. Griffith and Gittings (1907)	68	158	3.13	3.48	.35
29. Goldfeld (1912)	188	594	3.24	3.39	.15
30. Gini and Dettori (1913)	133	427	3.04	3.23	.19
31. Gini and Sfameni (1913)	378	741	3.10	3.25	.15
32. Gutfeld (1913)	2,870	2,025	3.22	3.39	.17
33. Hansen (1913)	1,283	4,540	3.46	3.70	.24
34. Kjølseth (1913)	224	269	3.41	3.64	.23
35. Peller (1913)	2,590	2,252	3.22	3.38	.16
36. Benestad (1914)	1,066	913	3.38	3.57	.19
37. Pearson (1914)		(1,722)	3.12	3.38	.26
38. Benedict and Talbot (1915)	38	61	3.38	3.69	.31
39. Lange-Nielsen (1918)		(7,190)	3.39	3.58	.19
40. Acosta-Sison and Calderon (1919)	457	780	2.78	3.01	.23
41. Adair and Stewart (1922)	149	149	3.31	3.50	.19
42. Collier (1922)	1,209	463	3.02	3.10 ¹	.08
43. Adair and Thelander (1925)	141	229	3.25	3.45	.20
44. Schiaffino (1925)	195	218	3.22	3.39	.17
45. Tyson (1928)	405	497	3.23	3.36	.13
46. Lee (1930)	487	950	2.86	3.15	.29
47. Martin (1930-31)	3,987	2,869	3.19	3.37	.18
48. Gerschenson (1931)		(12,065)	3.31	3.51	.20
49. Wardlaw and Dart (1932)	52	222 ²	3.43	3.70	.27
50. Jones and Hsaio (1933)	175	175	3.56	3.61 ³	.05
51. Peckham (1933)	9,300 ⁴	16,700 ⁴	3.22	3.43	.21
52. Toverud (1933)		(4,598)	3.45	3.63	.18
53. Bakwin and Bakwin (1934)	812	841	3.30	3.49	.19
54. Hanley (1934)	315	167	3.29	3.40	.11
55. Goldstein (1938)	172	294	3.22	3.39 ⁵	.17
56. Donald (1939)	2,001	1,085	3.26	3.43 ⁵	.17
57. Donald (1939)	235	235	3.32	3.42 ⁵	.10
58. Meredith and Brown (1939)	412	626	3.36	3.51	.15
59. Uttley (1940)	2,190	3,250	2.94	3.07	.13
60. Goldstein (1947)	61	140	3.06	3.19	.13

¹ Second-born; Collier reports means for birth orders 1 and 2 only.

² Authors attempted "to take approximately equal numbers" for the different birth orders — of the total, 144 are for orders 2 to 4 and 78 for orders 5 to 14.

³ Second birth order only, subjects drawn from the same families as first-born.

⁴ N's are approximate.

⁵ Limited to second, third and fourth birth orders.

⁶ Second-born; comparison utilizes 235 families with first and second siblings of like sex.

TABLE 2

Descriptive data pertaining to the studies included in table 1. The number assigned to a given study in table 1 (column 1) is retained in this table (column 1)

SOURCE OF SAMPLE Country and locality	SEX COMPOSITION		CRITERIA OF SELECTION AND PERIOD OF DATA COLLECTION
	Males	Females	
1. Berlin, Germany	...	...	Records from "1702 births."
2. Munich, Germany	...	...	154 "mature" newborn infants.
3. Leipzig, Germany	59	41	Over 2.5 kg, alive at 10 days.
4. Edinburgh, Scotland	...	...	2053 single, "term" neonates.
5. Munich (?), Germany	2,295	2,154	Live-born, single, 2.5 kg up.
6. Jena, Germany	770	718	Over 1.9 kg, amassed 1859-66.
7. Erlangen, Germany	201	182	Live-born, single, full-term.
8. Marburg (?), Germany	316	287	Full-term (none below 2.5 kg).
9. Marburg, Germany	1,064	936	2.8 kg up, 1850-70 data.
10. Copenhagen, Denmark	1,833	1,617	Records for mature children.
11. Berlin, Germany	345	285	"Full-term infants."
12. Paris, France	81	102	2.5 kg up, collected 1874-78.
13. Berlin (?), Germany	...	...	Over 2.3 kg, alive at 10 days.
14. Melbourne, Australia	100	71	Live, single, 2.0 kg up, 1879.
15. Budapest, Hungary	1,822	1,564	48 cm up, live-born, 1869-82.
16. Philadelphia, U.S.A.	330	381	White infants born 1865-72.
17. Dresden, Germany	4,110	7,610	Live-born, 48 cm up, 1872-83.
18. Edinburgh, Scotland	34	30	Normal, over 1.8 kg, 1889.
19. Paris, France	...	...	Live, normal, over 2.0 kg.
20. Bonn, Germany	...	...	Single, 38 wks. up, 1896-1900.
21. Tokyo, Japan	49	38	Japanese, full-term, single.
22. Halle, Germany	997	856	2.0 kg up, single, 1894-1900.
23. Baltimore, U.S.A.	...	...	"Negro," single, over 40 cm.
24. Baltimore, U.S.A.	...	...	White, single, over 40 cm.
25. Greifswald, Germany	26	22	Viable, single-born infants.
26. London, England	200	200	All regained weight by 2 wks.
27. Leningrad, U.S.S.R.	495	505	2.8 kg up, healthy, 1906.
28. Philadelphia, U.S.A.	111	115	White infants, "Not premature."
29. Würzburg, Germany	395	387	2.0 kg up, normal, 1903-12.
30. Bologna, Italy	287	273	From "Obstetrical Clinic" files.
31. Pisa, etc., Italy	...	...	"Pisa, Perugia and Cagliari."
32. Berlin, Germany	2,597	2,298	Live, 1.7% multiple, 1907-09.
33. Nykøbing, Denmark	3,005	2,818	Single births, decade 1900-10.
34. Oslo, Norway	270	283	Prenatal period over 38 wks. ²
35. Vienna, Austria ³	2,554	2,288	Single, normal, term, 1906-12.
36. Oslo, Norway	990	989	Term, viable, single, 1909-11.
37. London, England	856	866	Single, "normal time" infants.
38. Boston, U.S.A.	54	45	White, term, normal, 1914-15.
39. Oslo and Bergen, Norway	...	...	Term (over 2.7 kg), single.
40. Manila, Philippine Is.	...	...	Live-born "Filipino" infants.
41. Minneapolis, U.S.A.	...	...	Full-term (2.5 kg up).
42. Frankfurt-on-M., Germany	893	779	Single, live-born, 1920-21.
43. Minneapolis, U.S.A.	200	170	Over 2.0 kg, "normal."
44. Genoa, Italy	225	188	Data collected in 1925.
45. Philadelphia, U.S.A.	...	...	White and Negro, term, 1925-27.
46. Peiping, China	719	718	"Chinese," 2.0 kg up, 1922-29.
47. London, England	3,526	3,330	Infants "born alive," 1922-25.
48. Odessa, U.S.S.R.	...	...	Single, 2.5 kg up, 1921-26.
49. Sydney, Australia	145	129	Full-term, normal infants.
50. Berkeley, U.S.A.	186	164	Single-born, full-term infants.
51. Baltimore, U.S.A.	...	...	2.5 kg or 45 cm, ⁴ 1896-1930.
52. Oslo, Norway	2,382	2,216	Full-term infants born 1920-31.
53. New York, U.S.A.	818	835	"new-born . . . white infants."
54. Los Angeles, U.S.A.	250	232	White, term, single, viable.
55. New York, U.S.A.	...	...	Negro and White, "live births."
56. Edinburgh, Scotland	1,571	1,465	Live, normal, 38 wks., 1935-38.
57. Edinburgh, Scotland	286 ⁵	184 ⁵	Live, normal, 38 wks., 1935-38.
58. Iowa City, U.S.A.	533	505	White, over 2.5 kg, 1930-33.
59. Kwangtung, ⁶ China	2,784	2,656	Over 1.8 kg ("term"), 1934-39.
60. Mexico and U.S.A. ⁷	97	104	2.2 kg up, "Mexican" infants.

¹ Non-urban ("country practice") data amassed in the district of "Nykøbing on Sealand."

² Over 269 days from "fruitful copulation" or 279 days from "beginning of last menstruation."

³ About 60% from rural areas—mean birthweight for rural exceeded urban by 0.4 kg.

⁴ Viable Negro (54%) and White (46%) newborns having attained either 2.5 kg or 45 cm.

⁵ 143 pairs of males, 92 of females, from families with first and second sibs of same sex.

⁶ Parents lived "almost all . . . in the urban areas of Kowloon and Hong Kong, though a few came from neighboring villages."

⁷ Guanajuato, Mexico, and San Antonio, Texas.

(the non-first-born) outweigh the first-born by an average of 183 gm (6.4 ounces), or 5.7%.

Schmid-Monnard (1892) reported having found that the relationship at birth between birth order and body weight becomes reversed during the first postnatal year. Approximately 2,700 well infants were studied, the majority at Frankfort-on-Main by Dr. Lorey and about 400 at Halle and vicinity by Schmid-Monnard. The specific finding was that children of "old pluriparae" are heavier in early infancy than those of "young primiparae," but that the latter are the heavier in the last half of the first year. Schmid-Monnard generalized that by about the middle of the first postnatal year the average weight of first-born children begins to surpass that of later-born children, and by the end of the year the weight superiority of the former is clearly manifest. Additional evidence on this problem will be presented in the next section when the study by MacKinlay ('26) is reviewed.

In table 3 are displayed birth order findings on stature at birth from 29 different investigations. The arrangement of this table parallels that of table 1 on birth weight. As in table 1, each row begins with a number which enables the reader to locate the description of the sample in table 2. For example, the initial number of the third row in table 3 is 7: turning to table 2 one finds that Schroeder's investigation was made at Erlangen, Germany, on subjects characterized as full-term infants from single pregnancies born alive. A footnote to table 3 indicates that Schroeder had slightly fewer subjects for stature (199 males and 178 females) than for weight (201 males and 182 females).

Examination of table 3 shows that with two exceptions the obtained means for vertex-soles length on infants of multiparae are higher than those on infants of primiparae. Integrating the data from all of the studies, there are 24,146 stature records for ordinal position one, and 26,901 stature records for ordinal positions two and up. The mean of the latter exceeds that of the former by 0.34 cm (slightly more than one-eighth inch), or 0.7%.

TABLE 3

Body length at birth (cm) of first- and later-born infants, i.e. offspring (both sexes) from primiparae and multiparae. For the characteristics of any sample, see the row in table 2 beginning with the same number

INVESTIGATION	NUMBER OF SUBJECTS		MEAN STATURE		LATER- BORN LONGER BY
	First- born	Later- born	First- born	Later- born	
4. Duncan (1864)	1,011	1,042	48.8	48.8 ¹	0.0
5. Hecker (1865)	1,610	2,839	50.5	50.9	0.4
7. Schroeder (1869) ²	241	136	48.9	49.1	0.2
8. Pfannkueh (1872)	257	346	48.7	49.0	0.3
9. Sobbe (1872)	834	1,166	47.5	47.9	0.4
11. Fasbender (1878)	291	339	49.8	50.3	0.5
12. Budin and Ribemont (1879)	96	86	49.0	48.9	— 0.1
14. Woinarski (1879)	80	91	52.3	53.6	1.3
15. Kézmárszky (1884)	1,405	1,981	49.6	50.0	0.4
16. Stockton-Hough (1885)	423	288	48.5	49.3	0.8
17. Issmer (1887)	3,801	3,809	50.0	50.3	0.3
18. Keiller and Robertson (1890)	33	31	48.3	48.8	0.5
22. Willeke (1901)	943	910	51.1	51.7	0.6
23. Riggs (1904)	196	168	48.5	48.9	0.4
24. Riggs (1904)	370	227	49.7	50.0	0.3
29. Goldfeld (1912)	188	594	50.4	50.7	0.3
30. Gini and Dettori (1913) ³	127	410	49.1	49.7	0.6
31. Gini and Sfameni (1913)	373	734	48.6	48.9	0.3
32. Gutfeld (1913)	2,870	2,025	49.7	50.1	0.4
34. Kjölseth (1913)	284	262	50.7	51.3	0.6
37. Pearson (1914)	(1,722)		51.9	52.5	0.6
38. Benedict and Talbot (1915)	38	61	50.1	50.9	0.8
39. Lange-Nielsen (1918)	(7,190)		50.7	51.1	0.4
40. Acosta-Sison and Calderon (1919)	457	780	49.0	49.2	0.2
44. Schiaffino (1925)	195	218	49.8	50.2	0.4
52. Toverud (1933)	(4,598)		50.6	50.9	0.3
53. Bakwin and Bakwin (1934)	812	841	50.1	50.5	0.4
58. Meredith and Brown (1937)	413	627	50.2	50.7	0.5
60. Goldstein (1947) ⁴	43	135	49.8	50.1	0.3

¹ Since (a) the mean stature for the total sample is given as 48.7 cm and (b) the mean for the infants of primiparae occurs more than once in the paper, it is possible that the mean for infants of multiparae was somewhat less than the 48.8 cm reported.

² Sex composition of total sample, 199 males and 178 females.

³ Sex composition of total stature sample, 269 males and 268 females.

⁴ Sex composition of total stature sample, 91 males and 87 females.

Employing an alternative statistical method, Christie, Dunham, Jenss and Dippel ('41) corroborated the overall finding that first-born neonates are shorter than the aggregate of later-born neonates. Their data were accumulated between 1936 and 1938 "in the ward service of Johns Hopkins Hospital" on a total sample of 544 Negro and 563 White infants all "born alive . . . single born, non-syphilitic" (p. 472). For the White series, they found that of those measuring less than 50 cm at birth, 60% were first-born, while of those measuring 50 cm or more, barely 48% were first-born. Findings on the Negro series were 72% first-born among those with lengths less than 47 cm, and 55% first-born among those 50 cm and longer.²

Results on newborn subjects for numerous external dimensions of the body stem and extremities are exhibited in table 4. The evidence, taken as a whole, indicates that the average size of the calvaria, face, upper limbs, trunk, and lower limbs is slightly less in first- than in later-born neonates. The largest number of measurements is available for head circumference and the largest number of studies for head length and breadth. Composite means are greater on the later-born than on the first-born by .14 cm in head circumference, .06 cm in head length, and .08 cm in head breadth. These differences, from samples of 5,000 to 10,000 infants, reenforce the conclusion of Acosta-Sison and Calderon ('19) that there is "a slight diminution of the cephalic diameters in primiparae as compared with those of the multiparae" (p. 266).

Included among the dimensions in the lower part of table 4 from Bakwin and Bakwin ('34) are several pertaining to the face. These dimensions were not only investigated using a large sample, but all of the subjects were measured by the same anthropometrist (Miss Allene Jones). It will be seen that in every instance the direction of the relationship be-

²In making these analyses the White distribution was divided into two parts (those above and below the White average of approximately 50.0 cm) and the Negro distribution into three parts (those short, medium, and tall — the short being more than 1.5 cm under, and the tall 1.5 cm or more over, the Negro average of approximately 48.5 cm).

tween size of face and order of birth is the same. The means on first-born infants are smaller than those on later-born infants by .03 cm for upper and lower face height and intercanthus diameter, by .04 cm for breadth of nose and bizygomatic diameter, and by amounts exceeding .08 cm for bimalar and bigonial diameters.

The generalization that head size (size of the calvaria and face) tends to be larger in later-born than in first-born neonates is conspicuously unsupported by the means in table 4 for occipito-mental diameter. Directly relevant in this connection, however, are the analyses for occipito-mental circumference which support the generalization.

Table 4 carries findings on three measurements of the trunk — shoulder width, hip width, and girth of thorax. The findings on shoulder width and hip width are solely from Bakwin and Bakwin: they will be seen to harmonize with the prevailing trend, the means of primiparous infants being less than those of multiparous infants by .25 cm for biacromial diameter and .22 cm for bi-iliac diameter. In the case of the thoracic measurement, the obtained differences between the Bakwin and Bakwin means (from White subjects) and the Goldstein ('47) means (from Mexican subjects) are not in the same direction. The Mexican data afforded only 39 records in the first-born subgroup and necessarily held Goldstein to the indefinite conclusion that "chest girth of the first-born appears to be greater than in the later-born, although the difference is not statistically significant" (p. 8). The much larger sample accessible to Bakwin and Bakwin yields chest girth means that are not as great on the first-born as on the later-born, and the difference is significant at the 1% level of confidence.

Moving now to the extremities, table 4 presents the results obtained by Bakwin and Bakwin for measurements of the arm and thigh, forearm and leg, manus and pes. There is a total of 6 dimensions on each limb, and in every instance the mean for first-born neonates is lower than that for later-born neonates. The inference is obvious: again there is support for the generalization that at birth the average body dimensions

TABLE 4

Other measures of body size at birth (cm) for first- and later-born infants (offspring of both sexes from primiparae and pluriparae). A description of each sample is included in table 2, and may be found by study number

INVESTIGATION	NUMBER OF SUBJECTS		MEAN SIZE		LATER- BORN LARGER BY
	First- born	Later- born	First- born	Later- born	
Head circumference (occipito-frontal girth)					
7. Schroeder (1869)	156	88	34.7	34.6	— 0.1
11. Fasbender (1878) ¹	291	339	34.4	34.8	0.4
15. Kézmárszky (1884)	1,058	1,344	34.3	34.4	0.1
32. Gutfeld (1913)	2,870	2,025	34.3	34.4	0.1
34. Kjölseth (1913)	278	256	35.5	35.8	0.3
53. Bakwin and Bakwin (1934)	812	841	34.2	34.4	0.2
Head length (fronto-occipital diameter)					
6. Frankenhäuser (1867)	690	621	11.4	11.3	— 0.1
7. Schroeder (1869)	230	134	11.8	11.8	0.0
11. Fasbender (1878)	291	339	11.3	11.4	0.1
12. Budin and Ribemont (1879) ²	96	88	11.7	11.7	0.0
15. Kézmárszky (1884)	389	498	11.3	11.4	0.1
40. Acosta-Sison and Calderon (1919)	457	780	10.9	11.3	0.4
53. Bakwin and Bakwin (1934) ³	812	841	11.6	11.7	0.1
Head breadth (biparietal diameter)					
6. Frankenhäuser (1867)	690	621	8.8	8.8	0.0
7. Schroeder (1869)	230	134	9.2	9.4	0.2
11. Fasbender (1878)	291	339	8.8	9.0	0.2
12. Budin and Ribemont (1879)	96	87	9.4	9.4	0.0
15. Kézmárszky (1884)	397	506	8.9	9.0	0.1
40. Acosta-Sison and Calderon (1919)	457	780	8.9	9.0	0.1
53. Bakwin and Bakwin (1934)	812	841	9.2	9.3	0.1
Occipito-mental diameter (gnathion to occiput)					
7. Schroeder (1869)	230	134	13.6	13.5	— 0.1
12. Budin and Ribemont (1879) ⁴	96	87	12.9	12.9	0.0
40. Acosta-Sison and Calderon (1919)	457	780	12.8	12.8	0.0
Sum of fronto-occipital, biparietal, and occipito-mental diameters					
8. Pfannkuch (1872)	257	346	33.5	33.6	0.1
Occipito-mental circumference					
12. Budin and Ribemont (1879)	96	86	37.7	37.8	0.1
40. Acosta-Sison and Calderon (1919)	457	780	36.5	36.7	0.2
Suboccipito-bregmatic diameter ⁵					
12. Budin and Ribemont (1879)	96	87	9.9	9.9	0.0
40. Acosta-Sison and Calderon (1919)	457	780	9.4	9.6	0.2
Bitemporal diameter					
12. Budin and Ribemont (1879) ⁶	96	86	8.1	8.1	0.0
40. Acosta-Sison and Calderon (1919)	457	780	7.9	8.0	0.1
Stem length (sitting height)					
16. Stockton-Hough (1885) ⁷	423	288	31.7	32.5	0.8
53. Bakwin and Bakwin (1934) ⁸	812	841	33.8	34.1	0.3
Chest circumference (level of nipples)					
53. Bakwin and Bakwin (1934)	812	841	31.0	31.7	0.7
60. Goldstein (1947)	39	123	37.3	36.3	— 1.0

TABLE 4 — *continued*

MEASUREMENT	FIRST- BORN MEAN	LATER- BORN LARGER BY	MEASUREMENT	FIRST- BORN MEAN	LATER- BORN LARGER BY
Additional dimensions studied by Bakwin and Bakwin (1934)					
Intercanthus diameter	2.13	.03	Length of humerus ¹	8.53	.07
Palpebral breadth	2.14 ²	.03	Length of radius ³	7.10	.21
Bizygomatic diameter	7.25	.04	Hand length	6.37	.07
Bimalar diameter	7.05	.09	Palm length	3.63	.04
Length of ear	3.50	.02	Palm breadth	3.13	.04
Breadth of ear	2.43	.02	Middle finger length	3.29	.04
Nose height	2.12	.02	Lower limb length	21.76	.17
Nose breadth	2.10	.04	Length of thigh ⁴	11.96	.07
Upper face height	3.15	.03	Tibia-sole length ⁵	10.90	.20
Lower face height	1.74	.03	Length of tibia ⁶	8.61	.16
Bigonial diameter	5.66	.17	Length of foot ⁷	7.83	.17
Biacromial diameter	11.19	.25	Breadth of foot ⁸	2.99	.08
Bi-iliac diameter	7.30	.22	Span ⁹	50.25	.28

¹ Subjects "free from any head abnormality."

² Measurement taken from root of nose to most distant mid-sagittal point of occiput.

³ Measurement taken from glabella to most distant mid-sagittal point of occiput.

⁴ Also obtained "maximum diameter" (menton to most distal point, whether in occipital or parietal regions): reported means of 13.3 cm for first- and later-born.

⁵ From occiput-nape junction to anterior fontanelle at level of coronal suture.

⁶ Also studied bimastroid diameter: reported means of 7.7 cm for first- and later-born.

⁷ Length from "level of vertex" to "level of perineum."

⁸ Length from vertex to "most caudal point over the ischial tuberosities."

⁹ The number of subjects was 150 first-born and 111 later-born.

of infants of multiparae are slightly larger than those of infants of primiparae.

As mentioned previously, one measure of body form or shape has been studied on infants separated into the two categories "first-born" and "non-first-born." This study was made by Bayley ('36), covered the postnatal age period from one month to two years, and dealt with the shape of the head. The subjects were "predominantly 'Old Americans' largely of North European stock . . . living in or near Berkeley, California" (p. 1). There was a total of "26 first-born, and 28 non-first-born" subjects, and "the same children were measured repeatedly." Measurements of biparietal diameter and nasion-occipital diameter were obtained, and the index calculated for the transverse dimension times 100 divided by the anteroposterior dimension. It will suffice to reproduce the in-

dex means for 6 of the 15 ages between one month and two years at which they were reported:

	1 MO.		3 MOS.		6 MOS.		12 MOS.		18 MOS.		24 MOS.	
	N	Mean	N	Mean	N	Mean	N	Mean	N	Mean	N	Mean
First-born	23	77	26	80	24	84	23	83	20	83	19	82
Non-first-born	24	78	26	82	25	85	25	83	23	82	21	82

No systematic difference is registered over the period from six months to two years. Bayley summarized the trend in early infancy as follows: "The mean index of the first-born is smaller for the first four months of age, but the two means differ by only one or two points. This difference is too small to be significant" (p. 9). It is possible, of course, that a larger sample would substantiate the hypothesis that in early infancy first-born children are slightly more dolichocephalic than later-born children.

SIZE IN INFANCY FROM MORE THAN TWOFOLD GROUPING ON BIRTH ORDER

From about two-fifths of the investigations utilized in tables 1 to 4 it was possible to obtain body size findings for three birth-order subgroups. Most of these investigations employed, or could be recast into, the following trichotomy of ordinal categories: 1; 2-4; 5 up. A few reports neither used the category 2-4 nor presented data adaptable to its use: for these studies, the nearest threefold schema found practicable in all instances was 1, 2-3, and 4 up.

The results for a total for 48 tripartite analyses on newborn infants are shown in tables 5 and 6. These analyses have been extracted from 25 different studies published between 1864 and 1947. As in the preceding section, the materials for weight (table 5) will be discussed before attention is given to those for stature and other dimensions of the body (table 6).

Examination of table 5 readily reveals the fact that mean birth weight is less for first-born infants than for infants of second, third and fourth birth orders; and less for the latter

(category 2-4) than for those born fifth or later in the family birth series. The direction of this relationship is indicated consistently in the seriatim increase which characterizes the last three values of each row. The magnitude of the differ-

TABLE 5

Body weight at birth (kg) on infants in three birth-order categories. For a description of the different samples, see those rows of table 2 with corresponding initial numbers

INVESTIGATION	NUMBER OF SUBJECTS			MEAN WEIGHT		
	1	2-4	Birth-order category: 5 up	1	2-4	5 up
4. Duncan (1864)		(2,053)		3.26 ¹	3.30	3.34
5. Hecker (1865)	1,160	2,588	251	3.18	3.33	3.41
10. Ingerslev (1875)	1,723	1,496	231	3.25	3.40	3.50
16. Stockton-Hough (1885)	423	231	57	3.19	3.47	3.48
17. Issmer (1887)	3,801	3,269	540	3.19	3.31	3.42
20. Fourman (1901)	904	405	44	3.22	3.37	3.68
29. Goldfeld (1912)	188	357	237	3.24	3.36	3.43
31. Gini and Sfameni (1913)	378	447	294	3.10	3.20	3.32
32. Gutfeld (1913)	2,870	1,789	236	3.22	3.38	3.47
33. Hansen (1913)	1,283	2,719	1,821	3.46	3.67	3.75
34. Kjölseth (1913)	224	205	64	3.41	3.60	3.77
35. Peller (1913) ²	2,202	1,747	312	3.20	3.36	3.44
37. Pearson (1914)		(1,722)		3.12	3.31	3.48
39. Lange-Nielsen (1918)		(7,190)		3.39	3.59	3.68
46. Lee (1930)	487	582	368	2.86	3.14	3.18
47. Martin (1930-31)	3,987	2,394	475	3.19	3.37	3.40
49. Wardlaw and Dart (1932)	52	144	78	3.43	3.62	3.83
51. Peckham (1933)	9,300	10,500	6,200 ³	3.22	3.38	3.52
58. Meredith and Brown (1939)	412	421	205	3.36	3.47	3.59
59. Uttley (1940)	2,190	2,416	834	2.94	3.05	3.13
60. Goldstein (1947)	61	70	70	3.06	3.21	3.16
	NUMBER OF SUBJECTS			MEAN WEIGHT		
	1	2-3	Birth-order category: 4 up	1	2-3	4 up
11. Fasbender (1878)	291	292	47	3.20	3.36	3.42
22. Wilcke (1901)	943	705	205	3.25	3.43	3.51
30. Gini and Dettori (1913)	133	190	237	3.04	3.17	3.29

¹ This figure, from a table, differs slightly from the first-born weight (3.25 kg) given in the text of the paper.

² Records on 2,229 males and 2,032 females collected 1910-11 through three county maternity hospitals.

³ N's are approximate.

ences may be epitomized by obtaining composite means. Excluding the 3 studies that do not supply the number of subjects in each birth-order category (rows 4, 37 and 39) and the 3 in which the analysis is for categories 1, 2-3 and 4 up (rows 11, 22 and 30), there are 18 studies giving combined totals of 31,645, 31,780 and 12,317 in the birth-order categories 1, 2-4

TABLE 6

Body dimensions at birth (cm) for infants of three birth-order categories. Each sample is characterized in table 2, and is identifiable by row number

INVESTIGATION	MEAN STATURE			OTHER MEASUREMENTS		
	1	2-4	Birth-order category: 5 up	1	2-4	5 up
4. Duncan (1864)	48.8	48.7 ¹	48.5 ¹			
5. Hecker (1865)	50.5	50.8	51.0	<i>Mean stem length</i> ²		
16. Stockton-Hough (1885)	48.5	49.4	48.8	31.7	32.5	32.6
17. Issmer (1887)	50.0	50.2	50.5			
29. Goldfeld (1912)	50.4	50.6	50.8			
31. Gini and Sfameni (1913)	48.6	48.9	49.1 ³	<i>Mean head girth</i>		
32. Gutfeld (1913)	49.7	50.1	50.3	34.3	34.4	34.5
34. Kjølseth (1913) ⁴	50.7	51.1	52.0	35.5	35.7	36.1
37. Pearson (1914)	51.9	52.4	52.7			
39. Lange-Nielsen (1918)	50.7	51.1	51.3			
58. Meredith and Brown (1937)	50.2	50.6	51.0	<i>Mean chest girth</i>		
60. Goldstein (1947) ⁵	49.8	50.1	50.1	37.2	36.4	36.2
	1	2-3	Birth-order category: 4 up	1	2-3	4 up
				<i>Mean head girth</i>		
11. Fasbender (1878)	49.8	50.3	50.2	34.4	34.7	35.2
22. Wilcke (1901)	51.1	51.6	52.2			
30. Gini and Dettori (1913) ⁶	49.1	49.5	49.9			
	<i>Mean head length</i>			<i>Mean head breadth</i>		
6. Frankenhäuser (1867) ⁷	11.4	11.3	11.4	8.8	8.8	8.9
11. Fasbender (1878)	11.3	11.4	11.6	8.8	9.0	9.1

¹ N's for the different birth orders not given: the means for orders 2, 3 and 4 were averaged, as were the means for orders 5, 6 and 7 up.

² From "level of vertex" to "level of perineum."

³ N's are 373, 442 and 292, respectively.

⁴ N's are 284, 205 and 57 for stature; 278, 201 and 55 for head circumference.

⁵ N's for stature are 43, 59 and 76; N's for chest girth ("Guanajuato infants only") 39, 54 and 69.

⁶ N's are 127, 185 and 225; stature sample of 269 males and 268 females.

⁷ N's are 690, 566 and 55 for each dimension: 685 male and 626 female subjects.

and 5 up, respectively. The weight means from these samples are higher for category 2-4 than for category 1 by .166 kg (5.8 ounces); higher for category 5 up than for category 2-4 by .135 kg (4.8 ounces); and higher for category 5 up than for category 1 by .301 kg (10.6 ounces), or 9.4%.

Kézmárszky (1884) and Goldstein ('38) have each studied weight differences from comparison of first children with second, and second children with third, using successive offspring by the same mothers. The earlier study drew upon data for live-born infants exceeding 47 cm in stature, or 2.5 kg in weight, collected between 1869 and 1882 at the University Hospital, Budapest: Kézmárszky was able to obtain birth weight records on the first and second children of 77 mothers and on the second and third children of 62 mothers. Goldstein's data were selected from records on White and Negro infants born to ward patients at the Sloane Maternity Hospital in New York City. There were 172 mothers whose first and second pregnancies terminated in the birth of live-born infants, 90 whose second and third pregnancies resulted in live births, and 45 who gave birth to living infants from first and third pregnancies. Means (kg) from both studies are reproduced in the tabulation that follows:

INVESTIGATION	NUMBER OF SIBLING PAIRS	BIRTH ORDER CATEGORY:		
		1	2	3
Kézmárszky (1884)	77	3.26	3.39	
	62		3.38	3.41
Goldstein (1938)	172	3.22	3.37	
	90		3.37	3.42
	45	3.17		3.47

To quote Goldstein, "comparisons of sibs of the same family [indicate that] the third born are heavier than the second born and the second born are heavier than the first born" (p. 136). Attention is called to the fact that the differences between the means for first and second infants from Kézmárszky and Goldstein are a little larger than the difference of .10 kg obtained by Donald ('39) from birth weight records for 235

families having first and second children of the same sex (see table 1).

It has been shown conclusively that over the zone beginning with the first birth and extending up to at least the fifth, birth weight increases with ordinal position of the child in the family birth series. Does the increase continue beyond the fifth birth? The marked decrease in birth frequency with each successive order makes it difficult to obtain samples of sufficient size for adequate study of this problem. Investigators faced with a paucity of data for the higher ordinal numbers must choose between inconclusive results and the use of broad categories. Where investigators have had access to large samples the trend appears to be one of continuing increase. Two examples are studies by Peckham ('33) and Perlstein and Levinson ('37). Using a moderately large sample ("3,149 records of children born at Cook County Hospital and at Mount Sinai Hospital in 1928"), Perlstein and Levinson reported finding: "Birth weight increases with the parity of the mother up to the seventh parity" (p. 1645). Peckham, from the largest sample utilized to date (26,000 Negro and White infants born on the hospital or out-patient service of Johns Hopkins Hospital 1896-1930), concluded: "The smallest infants are born to primiparae. There is a steady rise in weight with increasing multiparity so that the average child born to a woman of para 10 or more weighs 12 ounces more than that of the primiparae" (p. 344). Specifically, Peckham's mean weight on approximately 1,200 infants "in the group para 10 and over" was .363 kg, or 11.3%, higher than that on the 9,300 infants "of the para 1 group" (p. 338).

Although there is a definite association between birth weight and birth order, the two variables are not highly related. This has been shown quantitatively by Simon ('25), Harris ('25-'26) and Goldstein ('38): each of these investigators reported the coefficient secured on a large sample of infants, using the Pearson product-moment method of correlation (r). The Harris sample consisted of 4,500 White infants born in New York City between 1890 and 1921; the Simon sample of 627

White infants³ born 1921-23 in Aussig, Germany; and the Goldstein sample of 614 New York City White and Negro infants for birth orders 1 to 4 only. The coefficients obtained were .19 (Simon), .18 (Harris)⁴ and .15 (Goldstein)⁵ — all positive, but low.⁶ Slightly higher coefficients probably would have resulted had the correlation ratio (Eta) been used instead of r . This follows since the relation of birth order to birth weight is perceptibly curvilinear, i.e., the difference in weight between first and second infants exceeds that between second and third, and the successive differences tend to become progressively smaller.

Findings for body weight in relation to birth order at the infancy ages of 1 and 12 postnatal months are available from MacKinlay ('26). The subjects, 916 at the younger age and 320 at the older, were "from working class families" living in slum areas of Glasgow, Scotland. They were weighed ("in special scales") at Glasgow Welfare Centres during the years 1919-23. The analyses made yield means representing four birth-order categories, and also correlation coefficients. The coefficients for age 1 month are $r = .08$ and $\text{Eta} = .18$, indicating a low positive association as at birth. At age 1 year, the relation appears to be of about the same magnitude but is negative in sign ($r = -.16$). The consecutive means from the birth-order subgroups afford an alternative portrayal of this reversal in direction of trend:

	1	BIRTH ORDER CATEGORY:		6 up
		2-3	4-5	
Mean weight at one month	3.53	3.79	3.88	3.80
Mean weight at one year	8.59	8.12	8.17	8.03

³ Not including stillbirths, multiple births, or premature infants.

⁴ Specific for sex, the coefficients from Simon were $r = .17$ (333 males) and $r = .22$ (294 females); the Harris coefficients $r = .21$ (2,300 males) and $r = .14$ (2,200 females).

⁵ A partial coefficient of .11 was secured by Goldstein for the relation between birth order and birth weight, with mother's age and duration of pregnancy held constant.

⁶ Since birth order is not normally distributed, the correlation coefficients cannot be statistically evaluated by means of the standard error.

In the language of MacKinlay, the weight "inferiority of the first born . . . is replaced at the end of the year by a definite superiority" (p. 248).

Turning now to stature and other dimensions of the body, studies for the infancy period that have made more than a dichotomous approach to the problem of birth-order differences include the 16 listed in table 6 and 3 by Kézmárszky (1884), Harris ('25-'26) and MacKinlay ('26). Reference to the stature portion of table 6, proceeding row by row, reveals that with one exception the means are smaller for the first than for the middle birth-order category, and in 11 of the 15 rows, smaller for the middle than for the last category. The same predominating pattern of increase in size with advance in birth order is seen for head circumference, stem length, and head length and breadth.⁷

For stature, composite values were derived using 8 series of means from table 6 (rows 5, 17, 29, 31, 32, 34, 58 and 60) and their corresponding N's (given partly in the footnotes to table 6 and partly in table 5). There were total N's of 9,071 for first-born infants; 9,130 for second-, third- and fourth-born; and 1,901 for fifth-born and higher. They gave means greater on the 2-4 category than on category 1 by .39 cm, and greater on the 5 up category than on category 2-4 by .11 cm. The mean for first-born infants was less than that for infants of fifth and higher birth orders by .50 cm (one-fifth inch), or 1.0%.

Keeping the same birth-order subdivisions and applying a different comparative method, Meredith and Brown ('37) found that of 413 first-born neonates, 40% were less than 50 cm in vertex-soles length, while of 205 infants of fifth and higher orders only 32% were less than 50 cm.

Kézmárszky (1884) published means at birth for stature and head circumference (cm) based upon records from the

⁷ Regarding the figures in table 6 for girth of thorax, the reader is referred to the earlier discussion of the Goldstein ('47) and Bakwin and Bakwin ('34) findings on this measurement.

first and second offspring in 77 families and the second and third offspring in 62 families. They follow:

NUMBER OF SIBLING PAIRS	Birth-order:	STATURE			HEAD GIRTH		
		1	2	3	1	2	3
77		49.9	50.2		34.2	34.5	
62			49.9	50.3		34.4	34.5

In each instance, sib 3 is larger than sib 2, and sib 2 larger than sib 1.

The association between birth order and birth stature, via the Pearson product-moment method, was investigated by Harris ('25-'26). Using data on 4,500 White infants born 1890-1921 at "the Sloane Hospital for Women, New York City," he obtained a coefficient of $r = .04$. Since the "true" relationship is slightly curvilinear (note that the difference above between the composite means for orders 1 and 2-4 is appreciably larger than that between orders 2-4 and 5 up), a slightly raised figure probably would have resulted had the correlation ratio been employed.

As in the case of weight, stature analyses at one month after birth and at age one year are available from MacKinlay ('26). All measurements were taken with the child "lying prone on a measuring board" (p. 35). For the 916 infants measured at the postnatal age of one month, the correlation coefficients were $r = .03$ and $\text{Eta} = .10$. The 320 infants 11 months older gave a negative product-moment value identical with that for weight ($r = -.16$). Means (kg) on the 4 birth-order subgroups reiterate this change from a low direct to a low inverse relationship:

	BIRTH-ORDER CATEGORY:			
	1	2-3	4-5	6 up
Mean stature at one month	51.8	52.4	52.8	52.4
Mean stature at one year	70.1	69.6	69.2	68.7

The question arises: What differential factor, or combination of factors, operates to produce this phenomenon? The answer is not yet known. Plausible factors include selective infant mortality (greater mortality among small infants, or among small infants of the lower birth orders), systematic variation in the duration of pregnancy (a slightly inverse association between birth order and length of prenatal period would produce a like relationship between birth order and rate of growth for stature and weight in infancy),⁸ and differential health care in infancy.⁹

BIRTH ORDER AND BODY SIZE IN CHILDHOOD

Within the age period 5 to 14 years, investigations on body size and birth order have been made by Boas (1895, 1898), Ewart ('12), Reiter and Ihlefeldt ('22) and Meredith ('48). In addition, the relation of grip strength to birth order has been studied by Carman (1899) and that of heart rate to birth order by Ciocco ('43).

Meredith ('48) accumulated measurements of stature, hip width, chest circumference and weight on 240 children 5 years of age residing in or near Iowa City, Iowa. All of the subjects were of northwest European ancestry and from the professional or managerial socioeconomic groups: there were 120 first-born (60 of each sex) and 120 second- to fourth-born (60 of each sex). The data were collected 1940-48 on children within three days of their fifth birthdays. Exceptionally rigorous anthropometric procedures were employed, each measurement being determined on the nude subject with two anthropometrists obtaining independent records. Hip width was taken at the crests of the ilia and circumference of thorax at

⁸ This follows since the younger the fetus or infant the faster the overall growth rate, i.e., rate of growth in gross body size decreases during the fetal and infancy periods.

⁹ From information on "reasonably healthy" and "badly nourished" infants, Gribbon ('22) found some support for the hypothesis that in families of low socioeconomic status health care tends to become "less satisfactory" with increasing size of family.

the xiphoid level. The following tabulation presents the means on the two birth-order groups:

BIRTH ORDER	AGE	NUMBER OF SUBJECTS	STATURE	HIP WIDTH	CHEST GIRTH	WEIGHT
	<i>yrs.</i>		<i>cm</i>			<i>kg</i>
1	5	120	110.8	18.1	54.2	19.3
2-4	5	120	110.0	17.9	54.2	19.3

No difference is registered for weight or chest girth, and the differences of 0.8 cm for stature and 0.2 cm for bi-iliocrystal diameter are not statistically significant ($t = 1.5$ in each instance).

Stature and weight values representing approximately 6 years of age were amassed by Ewart ('12) from measurement of over 800 children living in Middlesbrough, England. The sample was characterized as including "all those who were born in the year 1905 and . . . still living in 1911," except children of "the professional and monied class" (p. 205). Two categories were used in distributing the values for weight (first- and later-born) and three in distributing those for stature (1, 2-4, and 5 up).

BODY TRAIT	1		BIRTH-ORDER CATEGORY: 2-4				5 up		2 up	
	N	Mean	N	Mean	N	Mean	N	Mean	N	Mean
Stature (cm)	225	105.2	426	103.7	292	101.0				
Weight (kg)	204	18.2							662	17.5

The first-born children are heavier than the later-born by 0.7 kg (one and one-half pounds) and taller than the later-born ($N = 718$) by 2.6 cm (one inch). Both differences are statistically significant, as are the successive differences from the trichotomy of birth-order categories for stature.

About 1921, Reiter and Ihlefeltdt ('22) attempted to obtain measurements of stature and weight on all children born in 1910 at Rostock, Germany, and still living there. Of the 1910 total of 1,289 live-born, legitimate infants, 11% were deceased, 40% either had moved away from the town or were not acces-

sible for study, and 49% were studied. Those studied numbered 620 Rostock children approximately 11 years of age. Findings on body size in relation to birth order were as follows:

BODY TRAIT	BIRTH-ORDER CATEGORY:					
	1		2-3		4 up	
	N	Mean	N	Mean	N	Mean
Stature (cm)	191	139.6	262	137.6	177	135.6
Weight (kg)	191	31.2	262	30.9	177	29.8

Means for weight at birth were 3.47 kg on the subgroups 1 and 2-3, and 3.50 kg on the subgroups 4 up. In other words, on comparing at birth and in late childhood the weight means of the same 191 first-born children and 177 children of fourth and higher birth orders, Reiter and Ihlefeldt found little difference at birth (first-born lighter by 0.3 kg) and a difference of 1.4 kg (first-born heavier by 3 pounds) in late childhood.

Boas (1895, 1898) studied the relation of birth order to stature on school children of Toronto, Ontario, and the relation of birth order to stature and weight on school children of Oakland, California. The Toronto data were collected in 1891-92 under the supervision of Dr. Alexander F. Chamberlain and the Oakland data in 1892 under the supervision of Dr. Earl Barnes. Stature was taken "without shoes" and weight in "indoor clothing." Both samples consisted almost exclusively of children of northwest European ancestry.

The central tendency values for three birth-order subgroups are given in table 7, covering the age period 6 to 14 years on Toronto children and 8 to 14 years on Oakland children. It will be seen that decrease in mean stature with increase in birth order occurs "with such regularity that there can be no doubt as to the reality of the phenomenon" (1895, p. 404). On the whole, the means for first-born children are higher than those for second- to fourth-born by 0.5 cm, and higher than those for fifth- to tenth-born by 1.01 cm. Although the magnitude of these differences is small (e.g., one-fourth that obtained by Ewart), Boas was able to conclude: "It is . . . cer-

tain that first-born children are somewhat taller than later-born" (1898, p. 1596).

In the case of weight, the values in table 7 are less conclusive. While the first-born children, in general, are heavier than the children of later birth orders, inconsistencies occur and the overall difference does not exceed 0.3 kg. Comparatively, Boas' weight findings hold a position intermediate to

TABLE 7

*Stature (cm) and weight (kg) on school children of three birth-order categories.
Adapted from Boas*

AGE GROUP		BIRTH-ORDER CATEGORY:					
Mean	Range	1		2-4		5-10	
		N	Mean	N	Mean	N	Mean
<i>yrs.</i>							
Stature of Toronto children measured 1891-92							
6	5-7	386	108.9	1040	108.1	520	107.4
8	7-9	763	119.5	1568	119.0	904	118.6
10	9-11	860	128.8	1558	128.5	1004	128.0
12	11-13	710	138.7	1566	138.4	1000	138.2
14	13-15	477	150.1	1006	149.6	640	149.2
Stature of Oakland children measured 1892							
8	7-9	207	121.6	424	120.7	210	119.9
10	9-11	247	130.9	458	130.8	202	130.4
12	11-13	241	142.1	477	141.7	214	140.7
14	13-15	223	153.7	433	152.9	148	152.7
Weight of Oakland children measured 1892							
8	7-9	201	24.5	415	24.3	199	24.4
10	9-11	242	28.9	450	29.3	193	29.3
12	11-13	239	36.5	468	35.9	211	35.4
14	13-15	219	45.0	430	44.5	151	44.6

those of Meredith (no difference between first- and second- to fourth-born) and of Ewart, and Reiter and Ihlefeldt (differences of 0.7 kg between first- and later-born).

Records for maximum "strength of grasp" were analyzed by Carman (1899) from threefold subdivision on birth order. The subjects were public school children of Saginaw, Michigan — mainly "of foreign parentage of the laboring classes" (p.

393). A Collin hand dynamometer was used. Means on records of the left hand are:

AGE	BIRTH ORDER CATEGORY:					
	1		2		3 up	
	N	Mean	N	Mean	N	Mean
<i>yrs.</i>						
10	49	11	56	12	77	13
12	67	16	60	16	128	15
14	49	20	46	21	90	20

Obviously, no systematic association between birth order and grip strength is demonstrated.

Ciocco ('43) discovered "an unexpected relationship between the order of birth of the child and the duration of the cardiac cycle" (p. 171). His material consisted of 778 "stethograms made in the spring of 1940" on "the student population of an elementary school" at Hagerstown, Maryland. He found that "children of birth orders 1 and 2 have a statistically significantly shorter cardiac cycle, diastole, and systole than do children of birth order 3 or higher" (p. 173). When the duration of the cycle was expressed in terms of heart beats per minute (60/cycle duration), the following means were obtained:

BIRTH ORDER	AGE IN YEARS							
	6-7		8-9		10-11		12 +	
	N	Mean	N	Mean	N	Mean	N	Mean
1-2	120	93.2	133	82.5	122	82.5	72	79.3
3 up	83	87.1	99	80.8	79	80.5	70	77.3

For all ages together, elementary school "children of birth orders 1 and 2 have a heart rate 3 beats per minute faster than children of the higher birth orders" (p. 173). Ciocco concluded: "These findings apparently point to some influence of the maternal status during pregnancy — or possibly of either the maternal or paternal conditions at impregnation — on the growth and development of the cardiovascular system of the offspring" (p. 174).

SUMMARY

This paper brings together and integrates material from 70 studies on the relation of birth order to body size. It complements Howells' recent synthesis for early adulthood by extending consideration of the problem back through childhood to birth.

Findings at birth include the following:

1. First-born infants (offspring of primiparae) are typically smaller than later-born infants (offspring of multiparae). They are smaller in dimensions of the head, the trunk, and the extremities. For weight, stature, and head circumference the average differences are .18 kg, .34 cm and .14 cm, respectively.

2. There is a progressive, though diminishing, increase in body size with advance in ordinal position. Compared with neonates of fifth and higher birth orders, first-born neonates are shorter by .50 cm, or 1%, and lighter by .30 kg, or 9%. Mean weight for the tenth-born exceeds that for the first-born by .36 kg, or approximately 11%.

3. The correlation between overall body size and birth order, while positive, is low. Eta is estimated to approximate .10 for stature and .25 for weight.

Major findings in late infancy and childhood are:

1. Contrasting with the direct relationship at birth, there is an inverse relationship between stature and birth order during the period from 1 year after birth to 14 years. All of the available investigations within these age limits report higher means on first-born children than on children of later birth orders.

2. The "true average amount" by which the first-born are taller than the later-born during the childhood years probably is not less than 1.0 cm — differences between the means of specific studies vary from 0.5 cm to 4.0 cm.

3. Body weight in late infancy and childhood is not positively related to birth order: on the question of whether the two variables are independent, or inversely related, the presently accessible materials lend more support to the latter view. Two studies, for ages 6 and 11 years respectively, find the

mean weight of first-born children to exceed that of later-born children by 0.7 kg, while two other studies, for ages 5 and 8-14 years respectively, yield differences in mean weight (first-born minus later-born) of 0.0 kg and 0.3 kg.

Attention is directed to the high concentration of investigations at birth, the complete lack of information at ages 2 to 4 years, and the need for broader study at all post-neonatal ages. The only investigation in late infancy is on children of low socioeconomic status, and the only measures of body size that have been studied in the period 6 to 14 years are stature and weight.

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ADDENDUM

Since preparing the above article the author has secured access to two additional studies:

- WAGNER, GUSTAV 1884 Beobachtungen über Gewicht und Maasse der Neugeborenen. Königsberg in Pr.: R. Leupold's Buchdruckerei, 70 pp.

Wagner's data were collected on 1,500 newborn infants (811 males, 689 females) delivered at Königsberg during the years 1866-1882. Neonates weighing less than 2.0 kg or having a stature below 38 cm were excluded from the sample.

	BIRTH ORDER CATEGORY:		
	1	2-4	5 up
Number of infants	550	852	98
Mean:			
Weight (kg)	3.28	3.46	3.51
Stature (cm)	46.2	47.6	48.9
Shoulder girth	34.0	35.6	36.9
Head girth	34.3	34.7	35.3
Head length	10.4	10.8	11.2
Head breadth	9.0	9.0	9.2

- SIESEL, PROSPER 1905 Ueber wiederholte Geburten derselben Frau in bezug auf Gewichts- und Längenverhältnisse der Kinder und in bezug auf die Geburtsdauer. Strassburg, 29 pp.

Siesel reports birth weight records for 709 infants and birth stature records for approximately half this sample. No subject in the series weighed less than 2.7 kg.

	BIRTH ORDER CATEGORY:					
	1		2-4		5 up	
	N	Mean	N	Mean	N	Mean
Weight (kg)	212	3.27	415	3.40	82	3.52
Stature (cm)	134	50.4	230	51.0	..	...

The records include birth weights for the first and third infants of 56 mothers. Weight means (kg) for these newborn infants of the same mothers are as follows:

First-born:	N	Mean	Third-born:	N	Mean
	56	3.31		56	3.43

ERGOGRAPHIC STUDY OF HAND DOMINANCE¹

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FOUR FIGURES

Laterality in the functional preference of homologous structures has engaged the attention of man from ancient times (Wile, '34) and found expression in the folk literature of Shakespeare (Walsh and Pool, '42). When and why dextral dominance was developed is unknown (Brain, '45). How functional asymmetry establishes itself has been subjected to exhaustive observation by Gesell ('47). The voluminous literature on handedness of the early years of the last quarter century was summarized in 1933 by Downey. Recent interest has focused especially on the relation of hand and eye dominance to reading defects and speech disorders (Eames, '34; Chester, '36; Cole, '38; Hopkins, '39; Johnson and King, '42; and Byrom, '48) but the neurological basis of these and other laterality associations have yet to be established unequivocally (Peterson and Fracarol, '38; Smith and Akelaitis, '42; Smith, '45). Ledényi ('34) attributes right-handedness to cerebral circulatory inequalities caused by man's orthograde stance which is in itself asymmetric (Hellebrandt et al., '43).

Many methods of studying handedness have been devised (Buxton, '37). These have given rise to various concepts of the laterality distribution of the general population which are dependent on the criteria employed and the specificity

¹This study was supported in part by the Office of Naval Research (Project NR 172 092). The technical assistance of Angel Mary Krikorian is gratefully acknowledged.

with which this trait has been endowed by the investigator. Thus, Van Riper ('35) believes asymmetry of hand function to be distributed according to a bimodal curve with the right-sided mode predominant. Bijou ('38) challenges this view and Johnson and King ('42) present data in the form of dextrality quotients which fall into a unimodal distribution strongly normal in form.

Handedness is not an absolute behavioral quality. It signifies, rather, a degree of functional preference, and as such is subject to the multiple influences which account for normal physiological variability. Thus two problems arise when handedness scores fall along a continuum: first, the magnitude of preference necessary to indicate significant laterality; and second, the constancy with which the degree of dominance demonstrated is maintained. The purpose of this study was to observe the influence of physiological variations in stress on hand dominance. The data accumulated were subjected also to the incidental study of intra-individual variability in handedness.

METHODS

The subjects of the investigation were 65 normal adults, 23 male and 42 female. Observations were confined to wrist extension.² Bilateral differences in functional capacity were estimated from repetitive ergographic work. Two identical ergographs were available. Hence, both unilateral and bi-manual exercise was administered. The load lifted was sufficiently heavy to produce complete fatigue in approximately 8 bouts of 25 repetitive contractions separated by rest pauses of 30 seconds. Work was done as a two-count exercise to the beat of a visuo-auditory metronome set at 100. Exercise continued until the load assigned could no longer be lifted the requisite number of times at the prescribed rhythm. In 52 experiments the hands exercised singly, commencing

² The wrist ergograph has been described in detail elsewhere (Hellebrandt et al., '48). It was devised in cooperation with Professor L. E. A. Kelso of the School of Engineering, University of Wisconsin, and constructed by the late J. S. Hipple in the shops of the State of Wisconsin General Hospital.

with the dominant limb and alternating with the contralateral extremity; in 56 experiments right and left sided wrist extension were executed synchronously. The groups performing the two types of experiments were virtually identical. Work was computed by multiplying the load by the distance through which it moved. Work was done both in raising and lowering the load. The subjects were urged to make every contraction a maximal volitional effort. This demanded exceptional cooperation. Handedness observations were restricted arbitrarily to the sum of the work done in all paired bouts preceeding the one in which failure occurred. The functional capacity of the left hand is expressed as a percentage of the right. Thus values over 100 signify sinistral dominance; the smaller the number, the more intense is the dextral superiority.

Two types of stress were studied, the fatigue *per se* which is associated with the repetition of an exercise at a constant load and rhythm, and the exhaustion which accompanies progressive increase in the rate of working. The latter was the procedure in 36 paired experiments performed on a third group of subjects, approximately equal to the first two in number, but including more men. In these experiments the number of contractions executed per unit of time was invariable but the resistance against which motion occurred was graded by increments of .25 kg per bout until the weight was too heavy to permit continuation of exercise under the conditions imposed.

RESULTS AND THEIR INTERPRETATION

The column diagrams in figure 1 demonstrate that the laterality distribution of young adult subjects is unimodal and essentially normal in form, as suggested by Johnson and King ('42). In each instance the mode of the frequency distribution falls well to the left of the point of ambilaterality, indicating that the incidence of dextral functional superiority is relatively high. This is in keeping with previous work which shows a preponderance of right handedness in the general population. However, the mean degree of dominance

is moderate. Comparatively few subjects are strongly right or strongly left handed.

A point of interest is the shift in the mode of the frequency histogram toward the right when the two hands exercise concurrently (figs. 1 *c* and 1 *d*). Twenty-seven subjects performed both the unimanual and bimanual experiments. Of these, 70%

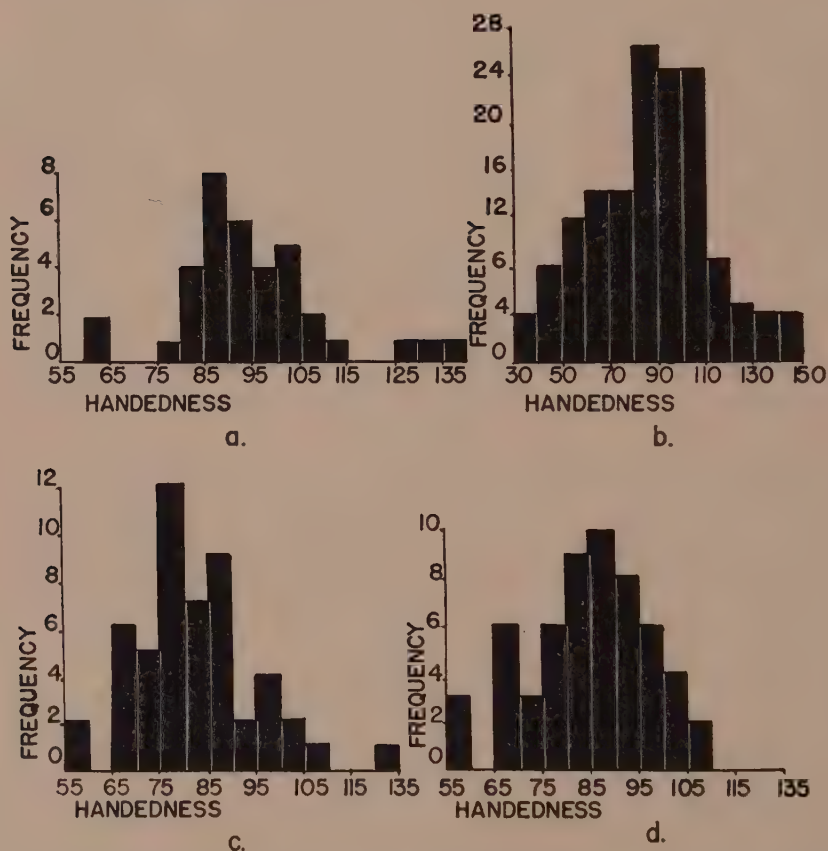


Fig. 1 The frequency distribution of handedness among young adult subjects under the following conditions: *a*. progressive increase in the rate of working; *c*. alternating bouts of right and left sided exercise performed at a constant rate of working; *d*. repetitive bouts of bimanual exercise performed at a constant rate of working. *b*. illustrates the intra-individual variability of the handedness of a single subject as measured by 300 maximal volitional contractions performed in alternating bouts of 25 contractions each.

showed a diminution in the degree of handedness during co-contraction of the dominant and the non-preferred hand. We have demonstrated recently that bimanual exercise is significantly dynamogenic (Hellebrandt and Houtz, '50). It augments the contractile power and endurance of the weaker side. This tends to make the two hands more nearly equal.

TABLE 1

Intra-individual variability in hand dominance. The data are presented in terms of Johnson and King's "Dextrality Quotient" (the percent of total achievement credited to the right hand)

SUBJECT AND SEX	CONTRAC- TIONS NO.	LOAD	D.Q.	SUBJECT AND SEX	CONTRAC- TIONS NO.	LOAD	D.Q.
		<i>kg</i>				<i>kg</i>	
T. F	250	1.50	59.47	B. F	475	1.00	57.70
	200	1.75	63.54		200	1.50	56.05
	125	2.00	52.65		125	1.75	53.91
	150	2.50	54.46	F. F	400	1.75	59.89
R. M	325	2.75	51.18		200	2.00	56.64
	25	3.25	53.12	H. F	50	1.25	53.30
J. F	150	1.50	56.38		100	1.50	55.62
	125	1.50	59.20	I. F	200	1.00	54.94
	200	1.50	43.93		200	1.50	59.91
	125	1.75	51.89	A. F	500	1.75	53.46
E. F	300	1.50	48.29		500	1.75	56.61
	175	1.75	64.18	M. F	200	1.25	56.39
D. M	150	2.00	59.79		200	1.50	49.31
	175	2.75	58.70		100	1.50	62.03
S. F	475	1.00	53.74	J. M	175	1.75	51.39
	300	1.75	54.09		175	2.00	51.23
C. M	125	2.50	52.52		125	2.25	52.10
	250	2.75	50.54		100	2.25	49.45

Fourteen individuals served as subjects for the alternating bout experiment more than once. The response on repeated tests is recorded in table 1. This suggests that the degree of handedness manifested by the same subject at different times is far from constant. The variance bears no obvious relation to the load carried or the size of the sample from which the mean is derived. Left sided dominance occurred in 11% of the trials, which is approximately its incidence in

the general population. However, it never occurred more than once in the same subject. The fact that the score attained on duplicate trials varies does not invalidate the method selected. Indeed, identical measures would invite suspicion, for the quality being evaluated is influenced by that variability which colors human behavior when work done exceeds levels of performance which can be easily accomplished. Inspection of the data in table 1 indicates that the intra-individual range of differences in the degree of functional asymmetry may exceed the mean limb preference exhibited on repeated testing.

Figure 1 *b* is based on 150 paired repetitive contractions, performed in unilateral alternate bouts of 25 contractions each, by a trained and reliable subject accustomed to the demands of laboratory testing. The height of each individual stroke recorded on a series of 6 paired ergograms was measured, using fine dividers, a magnifying glass and a steel rule accurately calibrated in millimeters. The data were then arranged in sequential order from the first to the last contraction in each successive bout, and the relation of the left to the right handed performance was computed. Intra-individual variability in the comparative functional capacity of the two sides was extreme and fell along a distribution curve essentially similar to those already described. The mode of the 6 individual bout frequency histograms, each based on 25 paired observations, shifted from virtual ambilaterality to weak sinistral dominance after a brief warming up period, and then toward increasingly strong dextral dominance under the influence of fatigue. Sequential stroke variability is illustrated in figure 2 *a* and mean handedness per bout in figure 2 *b*. The average handedness value for the total series of observations was 84.68. The range of intra-individual variability was several times greater than the mean superiority of the work capacity of the right wrist joint extensors. Paired strokes were exactly equal in only 2% of the trials, but 35% of the observations fell within 10% of ambilaterality. The significance of the mean difference was not computed.

The evidence suggests that such treatment of the data might be of value in determining whether a diminution in the ambilateral use of the two extremities is characteristic of the more strongly dominant.

The subjects reporting left-handed functional preference were for the most part weakly sinistral when subjected to

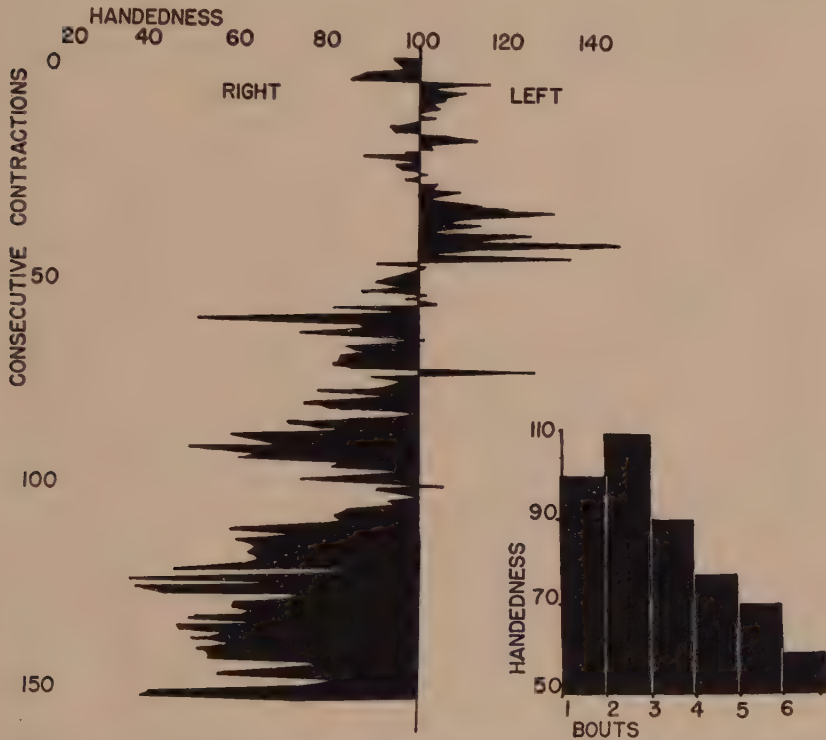


Fig. 2a Shifts in hand dominance during a single test composed of 150 paired contractions. 2b Mean handedness during the 6 successive bouts of the same test.

ergographic evaluation. Newman ('34), studying handedness in terms of an inborn morphological character, dermatoglyphics, makes the interesting observation that functional left handers tend to be double right-handed, lacking a true left hand. A large percentage of the left handers were ambidexters. Newman concluded from his evidence that hu-

man beings are not divisible into three well defined groups, right, left or ambidexterous, but that there exists a graded series of asymmetry types, ranging from pronounced right-handedness, which is relatively common, through weak right-handedness and ambilaterality to left-handedness. Those showing a real morphological asymmetry reversal were few in number. Brain ('45) has suggested that the truly ambidexterous are shifted sinistrals. Viewing the evidence in toto, it is highly probable that further study of functional capacity

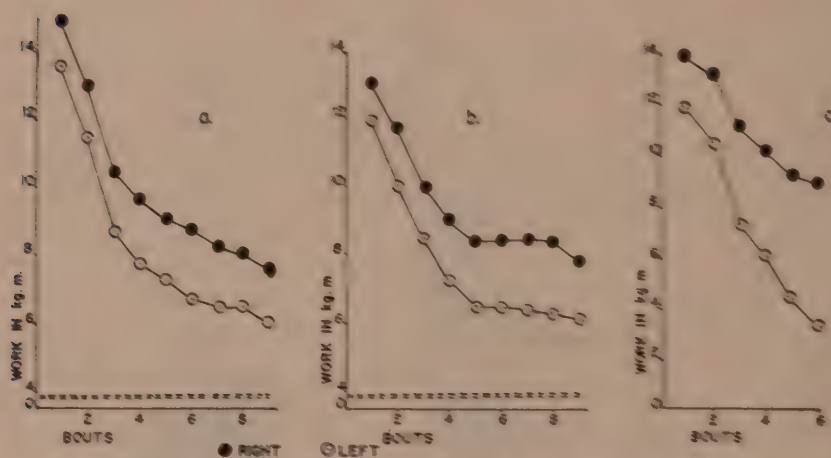


Fig. 3 a and b. The mean fatigue curves of the right and left extremities performing 8 bouts of repetitive bimanual and alternative unimanual exercise respectively. c. Fatigue curve of a well trained subject, moved to the discomforts of exercise in the overload zone.

data like that yielded by ergography, may also demonstrate the functionally left dominant to be, in fact, double dextrals with ambilaterally equivalent power and endurance.

Fatigue *per se* differentiates the weaker from the stronger side. This is demonstrated in figure 3, which includes both mean group and individual test data. The fatigue of the left side proceeds at a rate exceeding that of the right. Thus differences in functional capacity become increasingly evident as the limits of performance are approached.

Progressive increase in the rate of working appears to be one of the simplest methods of identifying significant degrees of asymmetry in function. This is illustrated in figure 4. Under mild stress the two hands perform equally well. This was uniformly observed, irrespective of the degree of functional preference. However, as the stress increases, asymmetry in functional capacity becomes more and more sharply

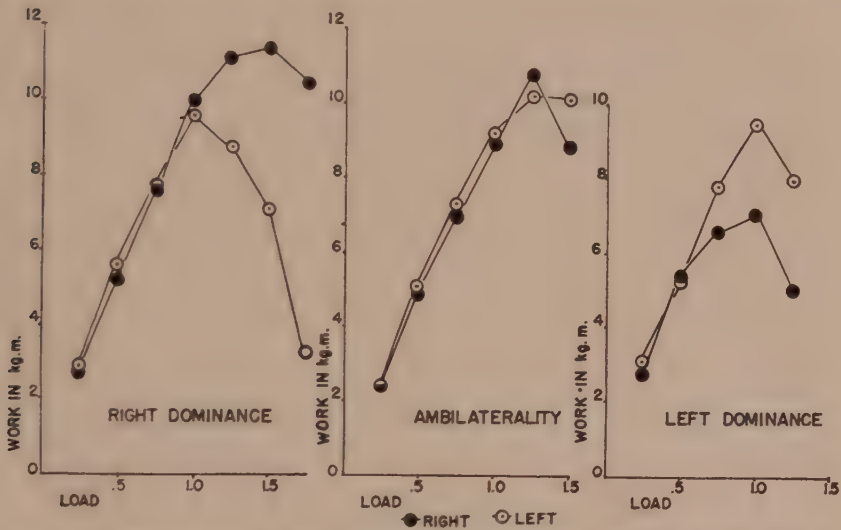


Fig. 4 Differentiation of handedness by progressive increase in the rate of working.

differentiated in those who manifest laterality. The preliminary observations suggest that the relative difference in performance at that point in the curve of work where optimum functional capacity is demonstrated may be a sound and defensible criterion of laterality. This hypothesis deserves further study. Differences in functional capacity based on total work are subject to the various augmenting and inhibiting influences affecting multiple bouts, whereas that of the criterion proposed reduces these to the single period in which the load is optimally adjusted to the rhythm of contraction. At this time the effects of fatigue have not yet made them-

selves felt and the muscle groups concerned have had the full benefit of whatever facilitation derives from the warming-up phase of the work assignment.

The problems posed in this discussion of handedness have practical implications. Handedness is an inborn trait that may be modified or reversed by training. That reversal sometimes affects behavioral development, appears to be supported by considerable clinical evidence, especially in relation to speech. If a child with a strongly dominant right hand develops a cerebral palsy characterized by a lesion of the left motor cortex and the clinical picture is complicated by seizures, persistent use of the right hand may increase the incidence and severity of the convulsions (W. M. Phelps, personal communication). It has been observed that the condition of the patient may be alleviated by avoiding the use of the right hand and shifting preference through training. Since the neural pathways of speech reside in the dominant hemisphere, reliable estimates of handedness may be important for diagnosis. The evidence thus obtained expedites localization of lesions responsible for aphasia (Brain, '45). Finally, human disability evaluation is frequently complicated by inadequate information relative to the incidence and range of physiological differences in the functional capacity of homologous structures. This is particularly true when pathological anomalies involving the upper extremities are subjected to quantitative study to aid in the adjudication of compensation claims. The degree of residual disability sustained in unilateral injuries cannot be evaluated accurately without reliable information as to norms of physiological asymmetry.

SUMMARY AND CONCLUSIONS

The influence of variations in stress on hand dominance was studied on 65 normal adult subjects. Differences in functional capacity were estimated from 144 ergographic work experiments. Observations were confined to wrist extension.

Both unimanual and bimanual exercise was administered. The evidence supports the following conclusions:

1. The laterality distribution curve is unimodal and essentially normal in form.
2. The mean degree of functional superiority is moderate and falls to the dextral side of ambilaterality.
3. Bimanual exercise tends to equalize functional performance.
4. Both hands perform equally well under moderate stress and differences in handedness cannot be evaluated.
5. Fatigue augments asymmetry in functional capacity.
6. Hand dominance is subject to wide physiological variation.
7. It is postulated that the relative difference in performance at that point in the curve of work where optimal functional capacity is demonstrated, may be a sound and defensible criterion of laterality.

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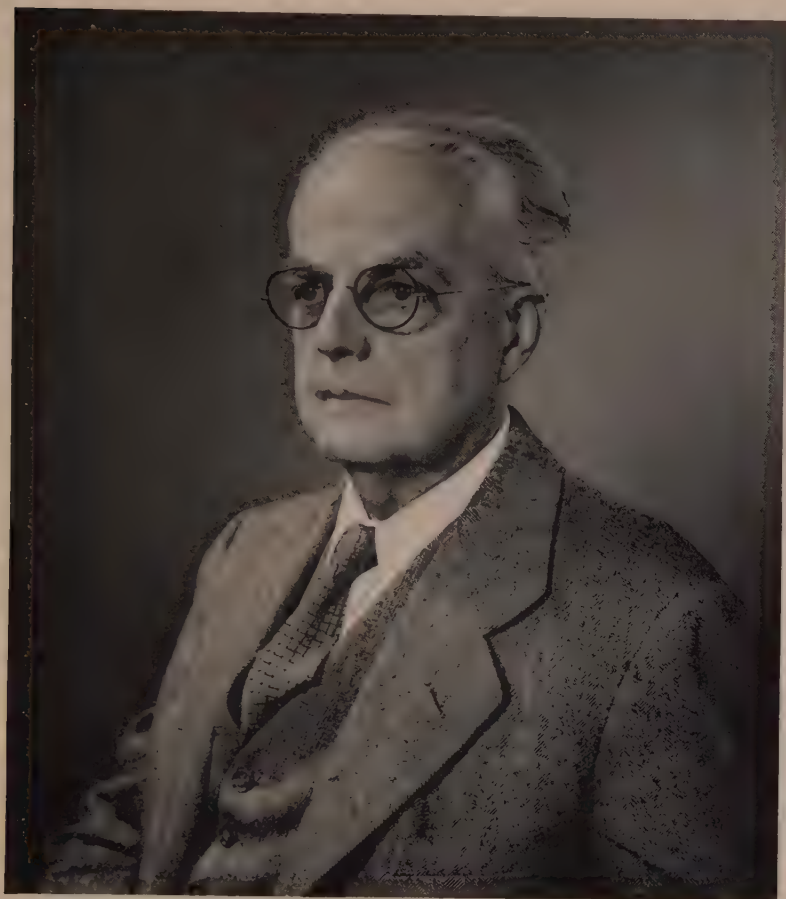
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NOTES

WILLIAM KING GREGORY

FOURTH RECIPIENT OF THE VIKING FUND MEDAL
AND PRIZE IN PHYSICAL ANTHROPOLOGY



(Photo by American Museum of Natural History)

WILLIAM KING GREGORY

The annual Viking Fund Awards were made on February 10, 1950, at a dinner given by the Viking Fund at the Waldorf Astoria in New York. The speech of presentation to Dr.

Gregory was made by Dr. T. D. Stewart, and is given herewith:

"The nominee of the American Association of Physical Anthropologists for the Viking Fund Medal and Award in Physical Anthropology for 1949 — William King Gregory — is a native New Yorker. He was born in this city, was educated at Columbia University, did most of his scientific labors at the American Museum of Natural History, and became a professor at Columbia University. It is fitting, therefore, that he should receive this well-merited honor from a New York foundation, albeit nominated by his colleagues at large.

"Dr. Gregory is now Emeritus Curator of Fishes and of Comparative Anatomy at the American Museum and Emeritus Da Costa Professor of Paleontology at Columbia. It may not be obvious at once to everyone why a paleontologist and comparative anatomist qualifies for an award in physical anthropology. This is explained by the fact that a physical anthropologist is identified by his point of view regarding man rather than by his attachment to a particular branch of science. Physical anthropology draws together from all sciences those who seek a broader biological perspective on mankind. According to this definition, indeed, Dr. Gregory qualifies as a *super* physical anthropologist. Where most physical anthropologists have been content to view man among the higher primates, Dr. Gregory has viewed man not only among all the primates, fossil and living, but even from the fish stage of evolution.

"Dr. Gregory's many publications in paleontology and comparative anatomy usually have dealt directly or indirectly with man. This has been newly impressed on me by recent reading and conversations with colleagues. For example, Drs. Romer and Washburn tell of Dr. Gregory's early understanding of the structure of the vertebrate skull and the help this gives in explaining the arrangement of the human cranial bones; and Dr. Eiseley values Dr. Gregory's beautifully detailed monographs on *Notharctus*, an Eocene primate, and points out that they show, among other things, the early arboreal adaptation of the primates.

"But most anthropologists associate Dr. Gregory's name with studies on the evolution of the human dentition and on the origin of man. The stimulus for these studies came largely from his colleague Prof. Henry Fairfield Osborn. Dr. Gregory also received from Prof. Osborn, and in turn modified, the so-called 'Cope-Osborn theory of Trituberculy.' This generalization sought to reduce the variable and complex cusp patterns of the molar teeth to the basis of a three-cusped ancestral stage. Out of the investigation of this theory and especially of its application to primate teeth grew the concept of

the 'Dryopithecus pattern.' In the lower molar teeth of *Dryopithecus*, a fossil anthropoid ape, Dr. Gregory found a pattern of cusps and grooves like that often seen in modern human molars, and especially among the more primitive existing races. This discovery led him to predict 'that the ancestors not only of the modern anthropoids but also of man would have the known generic characters of the jaws and dentition of *Dryopithecus*' (Anthrop. Papers A.M.N. H., 28: 30, 1926).

"The idea of a 'Dryopithecus pattern,' like other generalizations that Dr. Gregory has advanced, has been so widely adopted and utilized that his authorship is often forgotten. A recent letter from Dr. McCown gives a cogent explanation of this circumstance. He states as his belief that 'the real test of scientific greatness [is] to what extent any individual's work [becomes] incorporated into the common body of scientific knowledge without attribution to the particular individual.' He goes on to say that 'a very great part of Gregory's scientific contributions have been of such a fundamental nature that they have passed into the common body of knowledge and have within his lifetime become completely accepted but anonymous. I think there can be no question [Dr. McGown concludes] about the reality of this since even original contributions in the field of comparative anatomy and human paleontology accept as fundamental and without credit to Gregory ideas which, as we use them, were formulated by him. This situation is one which in nearly all the secondary sources is true without question.'

"Dr. Gregory's contributions demonstrate his knowledge of the history of science, his comprehension of evolutionary processes, and his broad powers of synthesis. These qualities are affirmed by Dr. G. G. Simpson in his recent 'Classification of Mammals.' There we read (p. 166): 'Gregory . . . has given an invaluable summary of the development of the classification of mammals from Aristotle to Weber. This book should be closely studied by every taxonomist.' And again (p. 187): 'I believe that Gregory has achieved the most valuable synthesis of the work of others, combined with his own very broad and detailed knowledge, and cite him as recent authority for the conviction, that the gibbons, apes, and man are a unit, derived from a common ancestor.'

"As this quotation indicates, Dr. Gregory has long maintained, as did Darwin, 'that man and the modern anthropoids in spite of widely divergent specializations, have inherited their innumerable structural and physiological correspondences from some very primitive and early member of the anthropoid group of Old World Primates' (Nat. Hist., 26: 309, 1926). At various times he has had to

defend this so-called 'simian theory of human origin' against the opposing views of such authorities as Profs. Osborn and Wood Jones. Currently the theory is challenged by Dr. Straus. As this debate has progressed, Dr. Gregory and his opponents have marshalled more and more evidence in defense of their views. From all this the science of man has benefitted.

"This is not the place to list Drs. Gregory's connections with various scientific organizations. I shall say simply that he is a charter member and past president of the American Association of Physical Anthropologists.

"Dr. Gregory, I would like you to know that your nomination by the Association for this Award was unanimous. I am sure that I speak for all my colleagues when I say that we value your friendship and cherish our long and stimulating contact with you. We look forward to receiving the monumental summation of your life's work now in press. May you have many more productive years!

"Dr. Fejos, on behalf of the American Association of Physical Anthropologists, I deem it an honor to present Dr. William King Gregory for the Viking Fund Medal and Award 'in recognition of the broad biological perspective he has brought to bear through paleontology and comparative anatomy upon the problem of the origin of man, particularly with his many valuable studies on the evolution of the human dentition.' "

The third recipient of the Viking Fund Medal in Physical Anthropology was Dr. Adolph H. Schultz, in recognition of his leadership in the investigation of primates. The award and medal were presented at a dinner at the Waldorf Astoria Hotel in New York on the 11th of February, 1949.

No notice of this was published in the *Journal* of last year and the Editor wishes to acknowledge the omission and record, however late, this honor to Dr. Schultz.

The Editor had obtained from Dr. Schultz the following sentiment regarding the bestowal of the award:

"I feel particularly gratified to have been chosen the Viking Fund Medalist of 1948 in Physical Anthropology because, by their selection, my colleagues have signified their approval of the *aims* of my work on primates and of its legitimate place in the science of man. During my entire research career I have tried to find whatever man may not have in common with his simian relations. Just when I am about to conclude that man is nothing but a rather poor primate, I find myself a very rich primate, not only by acquiring a beautiful medal and munificent award, but rich also through the esteem of my scientific co-workers."

THE BORDER CAVE SKULL, INGWAVUMA DISTRICT, ZULULAND

The accompanying photographs of the Border Cave skull were kindly furnished by Dr. Laurence H. Wells of the University of the Witwatersrand Medical School, Johannesburg. They have not previously been published, although the skull has been described with diagrams in an article entitled 'Fossil Man in the Lebombo Mountains, South Africa; the 'Border Cave,' Ingwavuma District, Zululand,' by H. D. S. Cooke, B. D. Malan and L. H. Wells (Man, 1945, no. 3).

Various fragments of the cranial vault, as well as other skeletal parts possibly belonging to the same individual, together with parts of the skeleton of an infant, were found in 1940, 1941 and 1942. The cave yielded fairly rich remains of the Middle Stone Age, capped by sterile rubble of roof-fall, and in places by a cemented red earth band; over this general level there were only superficial layers largely barren and apparently connected with Bantu occupation. The skull is confidently associated with the Middle Stone Age material, most probably with the Pietersburg culture, which would ally it in date to the Springbok Flats skull. The associated fauna is mainly of the modern low-veld type, but contains an extinct bovine and an equine appreciably larger than any recent zebra, provisionally identified as *Equus kuhni*.

The 1945 article should be consulted for a full description of the skull. According to the authors, it agrees well in size with the Springbok Flats and Fish Hoek crania, which were probably nearly contemporaneous, suggesting a type intermediate between these and the Florisbad skull (see A. Galloway, Am. J. Phys. Anthropol., vol. XXIII, pp. 1-17, 1937). The frontal bone is broad, with a well-marked, really continuous brow ridge, but both of these characters are less pronounced than in the Florisbad specimen. Other possible parts of this cranium are a right zygoma which resembles that of the Australians and is not at all Neanderthaloid, and an incomplete and toothless mandible which is non-Negroid and not prognathous.



Fig. 1 The Border Cave Skull Ingwavuma District, Zululand. Above, lateral view; below, facial view. Approximately one-half natural size.



Fig. 2 The Border Cave skull. Vertical view. Approximately one-half natural size.



CHEMICAL DATING OF BONE.—Citric acid can be observed not only in fresh bone specimens . . . but also in decreasing amounts, in bones which have been lying in the ground for thousands of years, exposed to the decomposing factors existing there.

As an indicator of the age of the bone the Ci-content can be used only with the greatest reservation and under special conditions.—T. Thunberg. The citric acid content of older, especially medieval and praehistoric bone material. *Acta Physiol. Scand.*, vol. 14, fasc. 3, 1947.

ROLE OF SALIVA IN TASTE BLINDNESS.—An individual will taste P.T.C. as bitter when the following two necessary conditions are met: (1) he must have the correct "taste apparatus," and (2) he must have his own saliva (or, presumably, its chemical equivalent). A nontaster cannot taste in any event, even when he uses the saliva of another taster. A taster cannot taste under any circumstances, except when he uses his *own* saliva; he cannot taste if he uses the saliva of another taster or non-taster. He can taste if he uses his own saliva, even though the saliva is placed on his tongue in exactly the same manner as the saliva from another individual. No subject can taste P.T.C. when the crystals are dissolved in water and no saliva is used at all.

Salivas are probably as different as fingerprints . . . Our finding that it must be the individual's own saliva may be brought about by the fact that the "taste apparatus" becomes, over the years, extremely sensitive and specialized to the particular saliva which the individual possesses; or these differences in saliva may be congenital or genetic. This being the case, when other saliva is introduced, it is equivalent to water, and no taste sensation results.—Jozef Cohen and Donald P. Ogdon. Taste blindness to phenyl-thio-carbamide as a function of saliva. *Science*, vol. 110, no. 2864, Nov. 18, 1949, pp. 532-533.

REVIEWS

GENETICS, PALEONTOLOGY, AND EVOLUTION. Edited by GLENN L. JEPSEN, ERNST MAYR, AND GEORGE GAYLORD SIMPSON, for the Committee on Common Problems of Genetics, Paleontology, and Systematics, of the National Research Council. Princeton University Press. xiv and 479 pp. 1949. \$6.00.

The twenty-three papers which compose this volume were given at the conference on Genetics, Paleontology, and Evolution, held at Princeton University in 1947. The purpose of the conference was to promote understanding and ultimately synthesis between the fields of genetics, paleontology, and systematics. Each of these sciences tries in its own way to understand the process of evolution, and so the nature of biological change poses a series of common problems which form the subject matter of this book. The chapters are divided into several main sections which are: viewpoints on evolution, evolutionary trends, evolutionary rate, speciation, and adaptation. There is a single essay on human evolution, an excellent summation by H. J. Muller, a useful glossary, and an index. Although the factual materials covered are extraordinarily diverse (including flies, frogs, birds, fish, various plants, reptiles, and numerous mammals), the common evolutionary problems are so universal and fundamental that the book has a surprising unity. The basic problem which gave rise to the conference is that the paleontologist studies the fragmentary fossil record, consisting almost entirely of bones, while the geneticist is primarily concerned with process, the mechanics of heredity and change. Most of the features studied by the geneticist are not available in fossils, nor can the experiments upon which the science of genetics rests be performed on extinct forms. It was this apparently great contrast (added to differences in vocabulary, journals, scientific associations, and places of employment), which led to a failure in understanding and communication between the two sciences. Obviously, both sciences deal with the change in form of plants and animals and many generalizations should apply equally well to both.

The contributors to this volume have tried to state the principles of modern genetics and systematics, and to see to what extent the results of paleontology may be understood, using the same concepts.

The theory of evolution shared by the majority of contributors may be briefly outlined as follows. Changes are due to random variations in the genetic structure of populations. Initial variations are produced by mutations and changing gene frequencies. Selection acts on the breeding population, adapting it to a way of life, the environment, and other populations. Thus selection determines the direction of structural change (within limits set by the genetic system). Such progressive adaptation is evolution. This concept of evolution differs very materially from that now current in physical anthropology, especially in the following ways: (1) The unit of study is the population, and emphasis is on adaptation. (2) The type specimen is no longer of paramount importance and typing a selected group of individuals out of a population is not permissible. (3) Using a few supposedly non-adaptive characters is not considered a proper way to trace phylogeny. (4) Evolution may and does reverse. (5) Apparent orthogenesis is due to a long-continued selection in one direction. (Only one contributor felt that natural selection could not explain all cases of apparent orthogenesis. Not one found Lamarckian ideas necessary.) Several contributors are concerned with evolutionary rates and trends. They believe that rapid evolution, after a certain threshold, creates apparent discontinuities in the fossil record and that there is no need to postulate a saltation or macro-evolution to account for the appearance of the higher categories.

The relation of gene to character is obviously of critical importance when relating genetic theory to systematic or paleontological investigations. Two chapters are primarily concerned with this problem, and the concept developed is that of the genes as the beginning of a chemical network, so that the vast majority of genes have many effects, and most characters are genetically complex. (Anthropologists looking for simple genetic explanations of complex characters take warning!) The demonstration that the same character may be caused by different genes or that the genetic basis for a character may change while the character is held constant by selection, leads to a re-examination of the concept of homology. Clearly phenotypic similarity is not proof of genetic homology. The implications and limitations of this discordance are not fully explored in this volume.

The changing genetic systems which cause evolution express themselves in structure. Yet only a single chapter is primarily concerned with anatomy, aside from the skeleton. D. D. Davis has provided an excellent review of the history of comparative anatomy and has given a series of cases showing the relation of particular anatomical adaptations to evolution and classification. (Taking the volume as a whole the paucity of detailed illustrations of this kind is surpris-

ing.) The theoretical picture is beautifully elaborated by the geneticists and trends are treated by the paleontologists. Racialization and speciation are considered successfully and in detail, but little emphasis is placed on genera and families, and it is at this level that modern comparative anatomy should be providing the connecting links between genetics and paleontology.

The discussions which ultimately culminated in "Genetics, Paleontology, and Evolution" were commenced at the meetings of the Geological Society of America in 1941. They were continued at Columbia University in 1942, and as a result the Committee on Common Problems of Genetics, Paleontology, and Systematics of the National Research Council was established in 1943. The activities of the Committee led to the founding of the Society for the Study of Evolution and the journal *EVOLUTION*. The present volume contains statements by committee members, and some others, which allow us to share in the deliberations and conclusions of the committee. The twenty-three contributors are an unusually able group. They had the benefit of several conferences, a mimeographed bulletin, and some years for deliberation before the papers for this volume were written. Finally, the contributions were revised after the Princeton Conference. The great value of "Genetics, Paleontology, and Evolution" arises from these very facts. It contains the considered statements of leaders in paleontology, genetics, and systematics on the most critical problems of evolution.

S. L. WASHBURN

University of Chicago

ANTHROPOLOGICAL PAPERS OF FRANZ WEIDENREICH, 1939-1948. A Memorial Volume. Compiled by S. L. Washburn and Davida Wolffson. The Viking Fund, Inc., New York. viii + 268 pp. 1949.

A compilation of some of the extremely important short papers of Dr. Franz Weidenreich, written during the last 10 years of his life, have been brought together into a Memorial Volume. The Viking Fund and the editors, S. L. Washburn and Davida Wolffson, have done physical anthropologists a distinct service in making these contributions readily available. The editors may also be congratulated for selecting representative articles from the wide range of Dr. Weidenreich's interests.

The volume includes thirteen papers, an account of Weidenreich's life written by Dr. W. K. Gregory and a complete bibliography. The papers are organized into three general groups. The first deals with

evolution in general. Included there is the stimulating late paper of Weidenreich's on the trend of human evolution in which he views the path of change as being orthogenetic toward specialization of posture and brain and finds himself unable to credit either chance mutations or general climatic environment for guiding the direction of this change. Other papers deal with the brachycephalization of recent mankind, the development of the human brain and the classification value of certain human characteristics.

A second group of papers includes general accounts of fossil man and emphasizes Weidenreich's opinions concerning the relationship of Neanderthal to modern man and of the anthropoids to man. A third category treats of specific fossil materials, particularly the Keilor skull and the child from Teshik-Tash Cave in Southern Uzbekistan.

One study on the relationship of form to function, a subject on which Weidenreich was deeply interested, is included. It is concerned with the formation of the external tubercle of the human tuber calcanei in response to the requirements of erect posture.

This useful volume, attractively lithoprinted, serves as a memorial to the activities of an outstanding figure in anthropology. Even though the contents are restricted to recent work of Dr. Weidenreich, it will serve as a constant reminder of the extent of his research and the quality of his achievements.

FREDERICK P. THIEME
University of Michigan



MAN AND ENVIRONMENT.—In presenting these few examples of problems relating to possible genetic factors which may determine adaptation to local climates in human races, I want to draw attention to our astonishing ignorance of what may be termed "racial physiology," and to the practical importance of its study. The need to pursue this field of study, indeed, is now leading to a radical change in the orientation of the subject of physical anthropology. This re-orientation of physical anthropology seems to me to be of the greatest

importance for the study of Man's relations to his environment. But it is only slowly being recognized, and has not yet found full expression in the teaching and practice of the subject. Physical anthropology is, of course, a historical subject in so far as it is concerned with the study of the organic relationship of the human species to lower animals, its evolutionary origin, and its evolutionary differentiation into races and sub-races. But it should also concern itself with actualities by the comparative study of living races and their geographical distribution, with special reference to problems of growth, physique and physiological efficiency in relation to the environment. Only quite recently, however, has it begun to take full cognizance of the environmental factors, and to make its own contribution to what is sometimes called "human ecology." Now, it is not easy to give a concise definition of this term "ecology," but broadly speaking it refers to the study of a particular situation as a whole, by attempting to integrate all the various factors upon which it depends so as to observe how they react to one another. It has been well said that only when the ecological viewpoint is developed does it become possible, by assessing all the factors concerned in a changing situation, to exert some controlling influence over them; the biological investigator, instead of being a sort of passive spectator recording and analysing what he sees, becomes in a sense an active participant in the scene. Compared with some other biological sciences, the subject of physical anthropology seems to have been rather late in entering on the ecological phase of its natural development, perhaps because, dealing with such a highly organized animal as Man, its problems have been vastly more complicated . . .

The importance and magnitude of these problems are such as to suggest the desirability of a Central Research Institute of Racial Physiology of commensurate size, and the training of physical anthropologists to carry out the preliminary field-work. So far as the colonies are concerned, it should be possible, through the Colonial Office, to effect contacts with administrative officials and the personnel of Government Medical Departments to arrange for co-operation in organising the field surveys and also to ascertain what, from their point of view, may be the most urgent problems on which the surveys might be able to contribute information. Each colony might have its own resident physical anthropologist as a Government official, maintaining a liason with the Central Institute for the purpose of co-ordinating field surveys and in order to ensure uniformity of technique. An organisation of this kind would of course require careful

planning, but it seems to me that the urgency of the present situation demands its serious consideration as soon as possible.— W. E. Le Gros Clark. *Fitting Man to his Environment*. Thirty-first Earl Grey Memorial Lecture, 1949.

PROCEEDINGS
OF THE NINETEENTH ANNUAL MEETING
OF
THE AMERICAN ASSOCIATION OF PHYSICAL
ANTHROPOLOGISTS

The nineteenth annual meeting of the American Association of Physical Anthropologists was held April 1, 2 and 3, 1950, at the Forsyth Dental Infirmary for Children in Boston, Massachusetts. Seventy-one persons were registered, including 43 members. Fifty-five persons attended the annual dinner at which Dr. William Gregory spoke on "Some Anthropological Consequences of Man's Place in Nature." In addition to the scientific sessions the members visited the Laboratory of Physical Anthropology at Peabody Museum on the afternoon of April first and were entertained by the Peabody Museum and the Department of Anthropology of Harvard University at an informal smoker at the faculty club that evening. On the afternoon of April 3, Dr. P. O. Pedersen showed motion pictures of his expedition to East Greenland.

BUSINESS MEETING

There being no corrections, the minutes of the eighteenth annual meeting, as printed in the Proceedings, were voted approved.

The Nominating Committee, consisting of Doctor Goff, Professor Steedman and Doctor Reynolds (chairman) presented the following nominees: for Vice-President, Dr. C. Wesley Dupertuis; for member of the Executive Committee, Dr. Stanley M. Garn. The nominees were elected unanimously.

The President requested that names of candidates for membership be presented to the Executive Committee in advance of the annual meeting so that adequate consideration may be given in every case. He pointed out that it would be helpful if names of nominees were accompanied by statements of their published work and other accomplishments. On the recommendation of the Executive Committee the following were elected to membership in the Association:

Spencer R. Atkinson	Thomas W. McKern
Arne Björk	P. O. Pedersen
Boyd Hayward	Erik Reed
Robert F. Heizer	James G. Roney
Francis Clark Howell	Elihu Schumann
V. O. Hurme	E. Carl Sensenig
Kalevi Koski	Charles I. Shade
George Maranjian	M. Stekelis

The Treasurer's report and the report of the Auditing Committee (Doctor Thieme and Mr. Gruber), as follows, were read and accepted.

TREASURER'S REPORT

Prudence Bond	\$ 100.00
U. S. Savings Bonds, maturity value	3,000.00
	<hr/>
	\$3,100.00
* * *	
Bank balance, April 7, 1949	\$1,705.60

Receipts

Dues	\$1,441.16
Viking Fund (for publication fund)	500.00
U. S. Savings Bonds, matured	2,000.00
Prudence Bond, disbursements	37.73
Sale of STUDIES IN PHYSICAL ANTHROPOLOGY	138.25
Interest on savings account	12.89

4,130.03

\$5,835.63

Expenditures

To Wistar Institute for subscriptions	\$ 391.50	
Secretarial expenses	79.89	
To W. M. Krogman (for 1949 Newsletter) .	50.00	
To Bertram Kraus (for 1950 Newsletter) ..	50.00	
To Wistar Institute for 300 copies of STUDIES IN PHYSICAL ANTHRO- POLOGY no. 1	540.04	
To W. W. Howells for publication fund	500.00	
Purchase of \$2,000 face value U. S. Savings Bonds, Series F	1,480.00	
To T. Dale Stewart (registration fee of the XXIX International Congress of Americanists)	10.00	
To Wistar Institute (for Proceedings)	41.15	
Bank charges, checking account	8.81	
		3,151.39
Bank balances, March 15, 1950		
Checking account	\$ 981.19	
Savings account	1,703.05	
		2,684.24
		<hr/> \$5,835.63

March 16, 1950
Respectfully submitted,
GABRIEL LASKER, Treasurer

Certified to be as stated above.

April 2, 1950
FRED P. THIEME
JACOB W. GRUBER

The Treasurer pointed out that on the date the balance was struck the Association had not yet paid for members' subscriptions for 1950 and that the balance in the Association checking account should be interpreted in this light. He recommended that the Secretary's budget of \$150 (including not more than \$50 to cover his traveling expenses to the next annual meeting of the Association) be approved, and it was so voted.

The Editor of the Journal, Dr. W. W. Howells, presented the following report of his activities, and a vote of thanks to the Editor for the quality of his work in assembling the Journal was unanimously carried.

REPORT OF THE EDITOR FOR 1949

"Volume 7 of the Journal was longer than usual, containing 612 pages. This was made possible by the generosity of the Viking Fund. The situation is as follows. The Wistar Institute operates our particular journal at a slight loss, as a rule, but allows us 500 pages a volume come what may, or 125 pages an issue. During Dr. Stewart's editorship, interest in the Journal picked up to the point where a constant supply of good articles could be relied upon. At any rate, there was a glut of such articles in 1949, which would have caused an undue delay in the publication of some of them had not the Viking Fund granted the Association \$500 for the special purpose of financing additional pages for the volume. This allowed a material expansion of the June and September issues and enabled the Journal to keep up with contributions. A general statement of expenses follows, in the form in which acknowledgment was made to the Viking Fund for its generosity:

Expenditures from this grant from February 1, 1949, through January 31, 1950 (together with some funds remaining from a previous grant), have been made on behalf of the American Journal of Physical Anthropology as follows:	
For volume 7, 112 excess pages	\$672.00
To pay for reprints from volume 7 for European contributors unable to make currency arrangements for this themselves (Vallois, Phansomboon et al., Chalmers et al., Prasad et al.)	37.38
	<hr/> \$709.38
Balance of grant on hand	\$375.63

The principal item of expense, and the original basis for requesting the grant, was for payment for extra pages for this Journal. This made possible the publication of approximately 6 extra articles in the volume, and allowed the necessary prompt publication of such articles as those of Vallois on the Fontéchevade crania, of Broom and Dart on new finds of the *Australopithecinae*, and Mourant and associates on Rh blood findings on new populations, without at the same time allowing these priorities to cause the accumulation and holding-back of research reports on other work in physical anthropology of the more usual kind.

The benefit to the Journal of this grant, for the above reasons, is most heartily acknowledged.

"Volume 7 contained 33 regular articles and the Proceedings of the Eighteenth Annual Meeting of the Association. It also contained 7 short articles in the form of Brief Communications — in some cases preliminary notices of new finds — and 10 book reviews. Sixteen articles were declined, totaling approximately 288 pages; this list, however, is so long partly because of a few left to my decision by Dr. Stewart; furthermore, the reason was invariably unsuitability to the Journal rather than lack of room, thanks to the Viking Fund. Out of 41 authors concerned in the production of the 33 principal articles of this volume, 18 or 44%, are members of the Association."

The Editor also discussed the problem of getting an adequate number of subscribers to the Journal. He said that with 200 more subscriptions assured the Journal could be permanently enlarged. It was pointed out that those who might be interested should be urged to subscribe directly to the Wistar Institute and that if they have the qualifications for membership their names should be submitted to the Executive Committee. It was also announced that Dr. Angel has been appointed an associate editor.

The Editor of the Newsletter, Dr. Kraus, was not present and submitted no report. The Association voted its thanks for his work and appropriated \$50 for the next annual issue.

The Award Conditions Committee, consisting of Drs. McCown, Washburn, Hooton, Schultz and Stewart (chairman), presented its report. After discussion, the following statement was adopted and the committee was discharged.

"The basis for the selection of nominees for the Viking Fund Medal and Prize was set forth in the original announcement of 1946 (see *Am. J. Phys. Anthropol.*, n.s. 4: 412). This specifies that nominees shall be 'such scholars who have made the most significant contributions in the three basic divisions of anthropology;' that the significance of a contribution shall be 'evaluated either in terms of the results achieved through research, experiment, and discovery, or in terms of published literary, historical and creative achievement;' and that no award shall be made 'if, in the opinion of the associations, no contribution worthy of the award has been made in a given field during the course of the year.'

"The awards,' the announcement further states, 'are to be made by the representative anthropological associations, upon the advice of committees appointed by themselves.'

"It will be noticed that the associations are not asked to furnish citations giving the reasons for their selections.

"Since it is the stated intention of the Board of Directors of the Viking Fund 'to make the conditions of these awards as liberal as possible,' already the practice of making the award on the basis of accumulated merit has become established. Thus, accomplishment has been divorced partly from the year of the particular award.

"So far as the American Association of Physical Anthropologists is concerned, actual practice in the selection of nominees has shown a lack of agreement on the following questions: (1) Which should take precedence as a basis of selection, accomplishment during a year or accumulated merit, and (2) how should the committee of selection operate? For the clarification of these questions, it is proposed that the Association adopt the following policy, which is not to be construed as a set of rules:

"1. The basis of the award shall be primarily a significant contribution during a particular year, and secondarily accumulated merit.

"2. In order to get more perspective on contributions, the period to be considered shall be the calendar year preceding that of the award.

"3. The examination of contributions and the selection of a nominee based thereon shall be carried out by a committee of three, to be known as the 'Awards Committee for 19...' to be appointed by the President at the annual meeting of the Association. The President shall be an ex-officio member of the committee.

"4. The Awards Committee shall entertain suggestions from members of the Association, provided the suggestions are given to its chairman before July 1 of the award year and are accompanied by detailed explanations.

"5. In order to avoid misunderstandings about the reasons for a selection, the report of the Awards Committee shall include a citation for public announcement and an explanation of its nomination for the information of the Executive Committee (it being understood that the Executive Committee gives final approval to the nomination, and that, if this approval is not given, no nomination will be made for that year)."

The Committee on Representation in the National Research Council presented the following report which was accepted with expression of gratitude.

REPORT OF THE COMMITTEE ON REPRESENTATION
IN THE NATIONAL RESEARCH COUNCIL

"In the Proceedings of the last meeting (*Am. J. Phys. Anthropol.*, 7: 277)

It was pointed out that the possible activities in research are limited by our professional isolation and that one way to deal with problems of research might be to associate ourselves with the National Research Council through the Division of Anthropology and Psychology. It was moved that the president head a committee to explore the matter. On the passage of the resolution, President Stewart appointed Doctors Bowles and Zwemer to serve with him.

"This committee held its first meeting in Dr. Zwemer's office in Washington early in May. As a result of this meeting, the Chairman on May 5 addressed a letter to Dr. A. Irving Hallowell, Chairman of the Division of Anthropology and Psychology, National Research Council, setting forth the Association's dissatisfaction with the present status of physical anthropology in the NRC and requesting that the Division arrange for a meeting of a representative group of physical anthropologists, and representatives of interested committees within the Council, to explore this subject. This letter was accompanied by a list of physical anthropologists who might be invited to such a meeting and by suggestions for the agenda of the proposed meeting.

"In due course Dr. Bronk, Chairman of the NRC, gave approval for this meeting and allotted the necessary funds. Immediately your committee decided upon June 6 as the most convenient date to hold the meeting. On that day, the meeting was called to order at 10:15 a.m. in the Board Room of the NAS-NRC Building. Present were the following physical anthropologists: Drs. Bowles, Howells, Krogman, Randall, Schultz, Shapiro, Stewart, Washburn and Zwemer (Executive Secretary, NRC). Present also were representatives of 12 NRC committees, including Dr. Hallowell.

"The meeting adjourned at 4:00 p.m., having voted

To recommend to the National Research Council that a committee on research in physical anthropology be established in the Division of Anthropology and Psychology to serve the following functions: (1) to foster and advance basic research in physical anthropology, and (2) to serve as an advisory body to interested committees of the Council.

"On June 17 Dr. Bronk approved the appointment of a committee on Research in Physical Anthropology, with the following membership: Drs. Bowles, Greulich, Howells, Randall, Schultz, Shapiro, Stewart, Washburn, and Krogman (chairman).

"Since the establishment of this committee in the NRC fulfills the purpose for which your committee was appointed, it is recommended that your committee be discharged."

In response to an invitation from the International Congress of Anatomists which will meet at Oxford, England, this year, it was voted that the President be authorized to name an official delegate.

The suggestion was made that the proceedings of the annual meeting might include reports of discussions as well as abstracts of papers and thus reduce the risk of having it thought that views expressed represent the position of the Association. During the discussion of this point it was brought out that there are serious difficulties in abstracting discussion and that it is usual and correct to assume that the Association can not and does not accept responsibility for material presented in the abstracts of papers but that this is the responsibility of individual authors. The suggestion to include discussion with the abstracts was therefore rejected. However, the motion was made that the abstracts of papers read by title not be published in the Journal and this motion was carried.

Dr. Washburn announced that those who wished to attend the fifteenth Cold Spring Harbor Symposium on Quantitative Biology, "Origin and Evolution of Man," June 9 to 17, might do so and that there are some accommodations available in the town of Cold Spring Harbor. The Viking Fund Summer Seminar is being planned for the week of June 19. It is hoped that Dr. Oakley will be able to come from England to attend the meetings and to describe the fluorine method for dating fossils. Other sessions will be devoted to a consideration of new techniques which would be applicable to physical anthropology, including statistical methods and casting techniques.

Dr. Washburn also informed the Association that the Society for the Study of Evolution would be willing to include in a mailing to its members a circular describing the American Association of Physical Anthropologists and the Journal provided that the arrangement were reciprocal. It was voted to authorize that this be carried out.

Dr. Reynolds delivered a cordial invitation from Dr. L. W. Sontag to hold the next annual meeting at the Fels Research Institute in Yellow Springs, Ohio. Antioch College joined in the invitation. Dr. Thieme also transmitted a gracious invitation to hold the next annual meeting in Ann Arbor at the University of Michigan, and Dr. Lasker stated that the Anatomists will meet in Detroit and that Wayne University would be pleased also to have the Association as its guests.

The Committee on Resolutions, Drs. Count, Ehrich and Dahlberg (chairman), presented the following resolutions:

"I. Whereas the Association has in the last year lost three of its members, William W. Graves, Francis E. Randall, and Morris Steggerda, be it resolved that the Association hereby expresses its deep sense of loss and extends its sincerest sympathy and condolences to the bereaved families.

"II. Be it resolved that the Association hereby expresses its gratitude to the Forsyth Dental Infirmary for Children for the use of its facilities during the 1950 meetings and to Dr. Howard M. Marjerison, its director, Dr. Stanley M. Garn, and to all the staff members who participated in the preparations for and in the conduct of these sessions.

"And be it resolved that we hereby express our thanks to the Department of Anthropology and to the Peabody Museum of Harvard University for their contributions to the program, both in making their collections available for inspection and for the very pleasurable social evening at the Harvard Faculty Club.

"And be it further resolved that these resolutions be incorporated in the minutes of this meeting and be published in the Journal of this Association."

These resolutions were unanimously adopted and the meeting adjourned.

SCIENTIFIC PAPERS

The titles and authors' abstracts of papers read at the session follow:

1. *Teeth in Neolithic Cyprus*. J. Lawrence Angel, Baugh Institute of Anatomy of the Jefferson Medical College, Philadelphia.

At Khirokitia Dr. P. Dikaïos excavated 123 broken skeletons (ca. one-third infants and children) dating ca. 4000-3500 B.C. and yielding a usable sample of 21 adults after skulls with artificial deformation (occipital) are excluded. Early

human remains from Iran to Spain lead one to expect a linear rugged Mediterranean population having almost perfect teeth deeply worn into the dentine. But the Khirokitia villagers, appearing "inbred," are stocky, Alpine (80%), and very brachycranial (C.I. 87). They have rounded, well-filled heads with low and wide foreheads, wide, squat, slightly angular faces, non-flaring but square jaw angles, proportionately narrow noses, and a complex of a dozen morphological traits almost uniformly peculiar to this local group.

By modern standards teeth are excellent, with rare pyorrhea or abscesses (2%). But as many as 11% of almost 800 teeth are lost or carious, with disease centering on the first molar region. And wear is only medium (molar cusps worn just to dentine). Though not differing much from Greece a millennium later, disease is greater and wear less than expected. Edge bites occur in 55%, with orthognathous mouth region, relatively prominent chin, little crowding, somewhat sloping chewing plane, and smooth-contoured temporomandibular joint: not features preventing teeth wear. And age at death for adults (32) is not unexpectedly young. This "civilized" lack of wear relative to other Neolithic and more primitive peoples may stem from such details in food preparation as use of hard volcanic rather than soft stone for milling grain. But the possibility of differences in enamel hardness has not been examined. In its small dental and skeletal peculiarities this Neolithic series emphasizes the potential significance of isolation, selection, and genic loss preceding the population mixture and increase during the Bronze Age in the Near East.

This study was made possible through travel grants from the Guggenheim Foundation and the Viking Fund.

2. *Posture, locomotion and the skull.* E. Lloyd DuBrul, Department of Anatomy, University of Illinois. (Introduced by Gerhardt von Bonin.)

In the Order Lagomorpha, evolutionary changes of the skull, of posture and of locomotion were studied. Changes in the skull, such as vaulting of the dorsum, ventral shift of the foramen magnum, decrease of the sphenoid angle, etc., were accompanied by changes from horizontal to semi-erect posture.

These changes are similar to those observed among the primates, and it is suggested that they be attributed to the influence of posture rather than to that of an expanding brain.

3. *Body build and specific gravity.* C. W. Dupertuis, Western Reserve University, School of Medicine.

A group of 81 Naval officers and enlisted men was studied to show the relationship between body specific gravity and somatotype. Specific gravity determinations were made by the method of hydrostatic weighing based on Archimedes principle. Results showed a high negative correlation between specific gravity and endomorphy ($r = -.853$) and a low positive correlation between specific gravity and ectomorphy ($r = +.369$). The correlation with mesomorphy was only $r = +.167$.

Approximately the same correlations were obtained between the components and the percentage of total body fat as determined from body water content computed by the antipyrine method.

4. *Spectrophotometry of living human skin in the ultraviolet range.* Edward A. Edwards, Nisson A. Finklestein and S. Quimby Duntley, Department of Anatomy, Harvard Medical School and Department of Physics, Massachusetts Institute of Technology.

An extension of former work on recording spectrophotometry of the skin of living human subjects was attempted by similar measurements extending into the ultraviolet region. The range was 240 to 600 μ . Readings were made of the reflectance values from various areas of several subjects, as well as transmittance measurements of some of the constituents of the integument.

Substances previously identified in the skin by recording spectrophotometry in the visible range were again noted. Of the many substances known to exhibit their characteristic absorption only in the ultraviolet zone, only one, vitamin A, was so far identified in the skin readings obtained through the reported method.

5. *The New World primates.* George E. Erickson, Department of Anatomy, Harvard University School of Medicine. (No abstract received.)

6. *The somatotyping of children: I. Standards; II. Constancy of the ratings.* Stanley Marion Garn, Forsyth Dental Infirmary for Children, Boston, Massachusetts.

If it were practicable to somatotype children and be certain that ratings given at an early age would hold, the study of constitutional differences in growth, development, and behavior would be furthered. At the Forsyth Dental Infirmary this problem is being investigated on 300 children in the Growth Study, and on 75 children followed from birth by Dr. Stuart, thus providing cross-sectional, semi-longitudinal and longitudinal samples. The existence of all three somatotype extremes, at each age level from 3 to 15 can be demonstrated; of the three components, mesomorphy has proved the easiest to rate at an early age. Because of age changes, children must be compared to other children of the same age, and not to adult standards. In considering constancy of ratings, such morphological features as back curvature and leg musculature remain relatively constant: others (such as trapezius development) follow a regular pattern and can be predicted. On the other hand indices such as the height/ $\sqrt[3]{\text{weight}}$ do not maintain a constant *relative* position; the standard score of this index is helpful in predicting the future physique only of extremes, and "channelwise" development is not the usual finding. Hence the problem of constancy of ratings can not be solved by body-build indices. Predicting the first component (endomorph) is still the major problem.

7. *The chemotype and the somatotype.* Menard M. Gertler, Harvard Medical School and Massachusetts General Hospital.

Current studies and studies in the past indicate that there is a general association between physical type and disease susceptibility. Such studies have indicated neither etiological factors nor the pathogenesis. However, by investigating the

serum biochemical constituents of the various physiques, an insight is obtained into pathogenesis and predilection to specific disease processes by the various physiques.

It was demonstrated that a definite physique-biochemical relationship exists with respect to at least two substances studied. Serum cholesterol is higher in the mesomorphs and endomorphic mesomorphs than in ectomorphs. Serum uric acid is higher in endomorphs and mesomorphic endomorphs than in ectomorphs. Those individuals who possess higher levels of serum cholesterol are called "steroid" individuals and are prone to diseases of steroid metabolism, such as atherosclerosis and some forms of cancer. Those individuals with higher uric acid in the serum are known as "xanthine" individuals and are more prone to gout.

It has also been shown that a physique differentiation exists with respect to the lymphocytic elements of the blood cells. This may help to explain the resistance and predilection of certain physiques to infectious diseases.

The role of serum constituents in "normal" physiques is redefined by this concept.

8. *The science of St. George Mivart.* Jacob W. Gruber, Temple University.

One of the important figures in nineteenth century biology, obscured by the dominance of Darwin, was St. George Mivart, the 50th anniversary of whose death occurred on April 1. Mivart's modern obscurity is due in part to his controversy with Darwin over the relative importance to be assigned Natural Selection in the origin and evolution of species. A prolific writer and indefatigable worker, Mivart produced some 73 scientific works in addition to many articles and books of a more philosophical nature. Though motivated to some extent by a basic religious conception, Mivart's opposition to Darwinism was based primarily upon scientific fact. He emphasized the inability of the doctrine of Natural Selection to explain all the observable phenomena, notably the variations within a natural population, an explanation of which he felt was basic to any hypothesis of species origin. Mivart ascribed such variations to an innate force through which new species arise, a process comparable, on the descriptive level at least, to the modern mutation hypothesis. Natural Selection, he felt, was powerless to originate useless variations although he did agree that it acted as a selecting factor — and so a secondary one in evolution — once the variations were initiated.

An ardent Catholic, Mivart assumed for himself the role of the reconciler of the seemingly contradictory areas of science and religion; and for almost half a century he fought for the acceptance of scientific discoveries by the Catholic Church. Eventually such an attempt to reconcile his religion with the discoveries of science as they contradicted the literal interpretation of Scripture led to conflict with Church authority; and, shortly before his death, he was excommunicated.

9. *Dynamic posture.* M. B. Howorth, New York.

Dynamic posture refers to the movements of the human body, and the positions of preparation for movement, as distinguished from static posture which is inaction. The basic dynamic position is a crouch, with the ankles, knees and hips flexed, the trunk inclined forward at the same angle as the lower leg. This position

is commonly assumed in sports but is also a useful position for arising, going up and down steps, walking on slippery surfaces, pushing, lifting, jumping, and for many of the occupational movements. Good dynamic posture reduces effort and fatigue, improves physical performance, and minimizes accidents.

10. *Physical welfare in the declining population of Yap.* Edward E. Hunt, Jr., Harvard University.

Angel and Hooton have shown that depopulations have been associated with physical deterioration at times in the histories of Greece and Pecos Pueblo, New Mexico. A third depopulation has occurred in the Micronesian population of Yap without such physical changes in the group.

The Yap population decline began late in the nineteenth century, with the first prolonged European contacts. In 1900 there were about 8,000 inhabitants, and now there are some 2,600. During the decline, the island culture and diet have remained remarkably unchanged.

The possibility of physical deterioration in this group was examined in several ways. Since no aboriginal Yap skeletons were available, a series from Guam, studied by Leigh, was used. The teeth in the aboriginal Guamanians and the modern Yapese are similar in having few caries, betel stains, and a loss of teeth in middle age.

Successive metric series of living Yapese dating from 1878 to 1948 show no significant changes in stature or head dimensions. Relative to less depopulated living Micronesians, the Yapese do not show excessive nasal pinching, facial elongation, or statural stunting. In fact, the Yapese children are among the most caries-free in Micronesia.

Yap women have few complications in childbirth, and since 1946 their reproduction has probably increased so that the crude birth rate in 1947 was over 30 per thousand.

These findings are not indicative of physical deterioration. The depopulation seems to have resulted from infectious diseases, induced abortions, and infrequent coitus. Today the Yap people seem to be holding their own.

11. *Variability in the emergence of incisors and canines in the rhesus monkey and in man.* V. O. Hurme, Forsyth Dental Infirmary for Children, Boston, Massachusetts.

The precise, statistically expressible degrees of variability in the eruption of teeth in man and other primates have not been determined. Biometrically valuable data on tooth emergence in *Macaca mulatta* have been collected by Prof. G. van Wagenen at Yale University during a period of 15 years. The records deal with observations on the deciduous and permanent teeth of animals born and bred in captivity. To date a part of the data on 53 normal females and 14 normal males have been analyzed. It is possible to compare the results with those obtained by the author after a summarization of reports dealing with the emergence of permanent teeth in 93,000 boys and girls.

No sex differences were found in the ranges of variation in the emergence of the deciduous incisors and canines. Likewise, the standard deviations for the two sexes

were approximately the same in so far as the 4 permanent incisor teeth were concerned. The permanent canine teeth showed much more variability in the female than in the male. The frequency distributions were asymmetrical for all teeth, resulting in means that were higher than the median ages of emergence. The sex differences between the means were unequal for all classes of teeth.

The data permit a comparison of the ages of emergence and exfoliation of individual deciduous teeth and their permanent successors. Incomplete analyses indicate clearly that late emergence of a permanent tooth connotes a longer-than-average period of mouth-exposure of its deciduous predecessor. Similar data are not available on the two dentitions of man.

12. *The scope and content of physical anthropology: a summary and an appraisal.* Wilton M. Krogman, Philadelphia Center for Research in Child Growth. (Read by title.)

13. *Congenital malformations of extremities.* Paul W. Lapidus, New York.

About 25 cases of congenital malformations of upper and lower limbs were demonstrated. Each individual case was photographed, x-rayed and pedigreed. These cases were selected from about 370 records of congenital malformations examined by myself while acting as Consultant Orthopedist to the New York Induction Station during World War II, and which were extracted from about 2,000,000 men mainly between 19 and 35 years of age (also from 16 and up to 45). About 150,000 draftees were personally examined by the author.

The congenital malformations are similar to ancient mosaic. A single stone of mosaic is meaningless, but when a large number of them are unearthed, the design of the mosaic stone can be reconstructed.

Since many congenital malformations are extremely rare, some occurring once in 100,000 or more births, the author had a most unusual opportunity to accumulate such a large number of congenital malformations within a short period of time, and has been able to figure out certain rules and patterns which the congenital malformations usually follow.

Congenital malformations of the extremities can be divided into two large groups: (1) progressive, such as polydactylism or gigantism, etc., and (2) regressive group, consisting of loss of digital elements or complete suppression of the extremity.

Large numbers of congenital webbing of second and third toes, frequently associated with webbing of third and 4th fingers, are recorded. Congenital fusion of tarsal and carpal bones associated with loss of thumb, and frequently with congenital radio-ulnar synostosis are recorded. Further analysis of this material is in progress.

14. *Morbidity and mortality among Eskimos.* Victor E. Levine, Creighton University School of Medicine. (No abstract received.)

15. *Caloric intake in relation to physique in children.* G. Maranjian and P. S. Peckos, Harvard University and the Forsyth Dental Infirmary for Children, Boston, Massachusetts.

It is the consensus of opinion that children who are rotund eat more than children who are linear in type. This belief was investigated in a group of children.

The caloric and protein intakes were calculated on 50 youngsters, chosen from the Orthodontic Department of the Forsyth Dental Infirmary for Children, and rated by Wetzel's classification of physiques—i.e., A4, A3, etc. According to current thinking the "obese" and "stocky" children maintain a higher caloric intake than the "fair" and "borderline" children as shown by a decline in calories from the A4 extreme to the B4 extreme.

This is found not to be true in the case of these 50 children. The results indicate the reverse of the expected. We have found that the caloric intake of the linear "B" group children exceed that of the rotunds with a decrease in calories from the extreme ectomorph to the extreme endomorph.

The dietaries of these children were taken for 7 days and an average computed. The average for each child was then compared to National Research Council Standards and the per cent calculated. The listing of the dietary was done at home by the mother, and amounts were reported in approximate household measures. In many instances the judgment of the mother was not wholly accurate: hence, the error introduced must be considered.

The results considered from the point of view of surface area and heat loss are logical, but considered with the problem of weight control, they become antithetical. They serve to intensify and at the same time enlighten this major problem, and help to show why the low caloric and high caloric diets do not have the expected results on extreme physiques.

16. *The crown root angle in anterior human teeth.* M. B. Markus, Graduate School of Medicine, University of Pennsylvania.

Series of measurements pertaining to size, especially crown length and breadth, have been published from time to time.

Certain problems have arisen in connection with a more critical analysis of dental morphology, especially as seen in lateral x-ray head plates, which necessitated the establishment of detailed and precise angular relationships on anterior human teeth.

Four angles were measured upon 600 teeth equally divided among central incisors, lateral incisors and canine teeth, upper and lower to establish an average and standard deviation for the crown root angle of the teeth.

It is quite possible that the crown root angle has some bearing upon the position and occlusion of the teeth.

17. *The Wallbrook frontal bone and the Swanscombe parietal.* M. F. Ashley Montagu, Department of Anthropology, Rutgers University.

The Wallbrook frontal bone was discovered about 1,000 yards northwest of the site of the London Skull, and may be derived from the same Upper Floodplain

Terrace. The geological conditions under which it was found are, however, ambiguous. The Wallbrook frontal is remarkable only for its thickness, particularly at the coronal suture. As Weiner has pointed out its thickness here is slightly greater than that of the Swanscombe parietal at its coronal suture. This fact disposes of one of the objections which has been urged against the possibility of the Swanscombe skull not having possessed a sapiens-like frontal. Though the Wallbrook frontal belonged to a slightly smaller skull than that of the Swanscombe skull, the two bones, the Wallbrook frontal and the Swanscombe parietal, when approximated to each other in their proper anatomical relationships, give an excellent fit. There can be no reasonable doubt that the Swanscombe parietal could very well have had a sapiens frontal bone, like the Wallbrook, attached to it.

13. *The dentition as a criterion of race with special reference to the Aleut.* C. F. A. Moorrees, Forsyth Dental Infirmary for Children, Boston, Massachusetts.

Advantages of the dental study in man are: to establish possible linkage in time and space between populations — differentiate within populations — study the influence of admixture — determine the mode of inheritance — add to the body of data concerning the dentition.

Data on the Aleut may illustrate some of these points. Morphologic and linguistic differences found in this population are supported by the dental study. Torus mandibularis was present in 61% of Eastern Aleuts (living east of Atka) against 26% in Western Aleuts (living in Atka and formerly Attu). C. R. 3.4. Mandibular prognathism occurred only in the Eastern populace (13%, C. R. 2.3). In part due to small numbers, the numerous other differences are not statistically valid.

The genetic study of torus mandibularis by Mr. Osborn offered a working hypothesis, that its presence depends on a single major gene, whereas the degree of penetrance depends upon two or more modifiers, cumulative in effect. On this basis, presence of torus mand. in 30% of children under 10 years is explained. A single recessive gene accounts for the incidence of mand. prognathism.

Crown length in Pecos Indians, East-Greenland Eskimos, and Aleuts can be used as one example illustrating variations within the Mongoloid race.

Variations of primary racial features of the dentition within sub-races should be studied attentively since pure Mongoloids, for instance, do not exist.

The ultimate value of the dentition as a criterion of race will depend on the outcome of detailed studies in populations of known racial origin.

19. *A comparison of adolescent growth curves in relation to the frequency of dental caries.* Dolores van C. Nourse, Washington.

Reported rampant caries in the teeth of Bermuda school children suggested the need for an investigation of dietetic conditions and economic standards in relation to the general growth pattern of the male and female, white and Negro school children between the ages of 11 and 15 years of age. When all available factors were statistically analyzed, it was found that only 51% of the children were carious and that those children of parents in the lowest economic and poorest dietetic brackets compared favorably in growth in height and weight with children of the

Baldwin and Richey studies conducted in the United States. In view of the fact that it was possible to check the genealogical background of the Bermudan children, the results of the study indicated that genetic factors in the constitutional makeup of the population accounted for the lack of vulnerability in growth in height and weight in carious adolescents.

Further comparisons were made with adolescent growth curves from the work of Boas on Puerto Rican males, the Jamaican study of Davenport and Steggerda, and the report of Steggerda and Hill; these showed that climate or nutritional factors by themselves, do not bear a direct correlation to the frequency of caries. The genetic background of the group under observation must be carefully studied in order to determine the expected growth curve during adolescence before assaying the extent of probable vulnerability resulting from caries.

20. *Thalamus of primates compared in gross dimensions and cell masses.* James W. Papez, Department of Zoology, Cornell University. (Read by title.)

21. *Surface studies of Eskimo teeth from Alaska and Greenland by means of shadowed replicas.* P. O. Pedersen, National Dental College of Denmark.

The development of replica techniques has provided a means for extending studies of Eskimo dental anatomy and pathology to include microscopic examination of enamel surfaces. The present study was carried out under a U.S.P.H.S. special research fellowship at the National Institute of Dental Research, National Institutes of Health, Bethesda, Maryland in collaboration with David B. Scott and Ralph W. G. Wyckoff.

I. Surface replicas. Metal shadowed collodion replicas for optical microscopy were made of (1) 1043 facial, lingual and proximal surfaces of 353 permanent teeth from 100 Alaskan Eskimo skulls in the Smithsonian Institution of Washington; (2) 600 surfaces of 189 permanent teeth extracted from 152 modern Southwest Greenland natives; and (3) 1075 surfaces of 565 permanent teeth from 240 Washington, D. C. dental office white patients.

Surfaces (2395) showing perikymata were classified according to perikymata course and distribution as either regular, medium or irregular. In the above group (1) 42% of surfaces showed irregular perikymata; in group (2) 58%; in group (3) 6%.

The disappearance of surface structure (enamel rod ends and perikymata) with advancing age was studied in the three samples. Similar rates of progression of structure loss with age were found. Grouping of surface replicas by age of individuals and degree of occlusal attrition of teeth showed that age is the important factor in smooth surface structure loss whereas conditions causing occlusal wear do not seem to contribute appreciably.

II. Visual examination. Inspection of all teeth involved showed higher incidence of surface irregularity (pitting and ring-shaped depressions) in Alaskan Eskimo (57% of teeth) and West Greenlanders (56%) than in whites under study (30%). No relation of such surface irregularity to perikymata irregularity could be established.

III. Dental fluorosis. Very mild, mild and moderate dental fluorosis was observed in Eskimo skulls from Shishmaref, Metlatavik and Wales, Seward Peninsula, Alaska as well as in teeth from Julianehaab District, Southwest Greenland. Dental fluorosis as found in this study does not account for the surface irregularities observed.

IV. Abrasion of teeth by labrets. Localized wear of facial surfaces of mandibular canine and premolar teeth due to wearing labrets was found in a number of Alaskan male Eskimo skulls.

22. Dental conditions and determination of individual age in anthropology and forensic medicine. P. O. Pedersen, National Dental College of Denmark.

Of the several changes occurring in teeth and their surrounding structures with advancing age, occlusal attrition is the one most commonly used in anthropology and forensic medicine as an aid to determination of individual age. However, since occlusal attrition is greatly influenced by a variety of environmental factors it is of limited value in age determination.

The purpose of this presentation is to call attention to two new and promising dental approaches to age determination. Scott, Kaplan and Wyckoff (*J. Dent. Res.*, 28: 31-47, 1949) established the rate of progression of wear with age on facial, lingual and proximal surfaces of teeth in a group of American whites. Using their results as a base-line we found very much the same age-wear progression pattern in both Alaskan Eskimo skulls and modern West Greenland natives. In the latter groups as in the whites individual age could be estimated with a fair degree of accuracy by means of surface replicas of a few teeth from each individual. This also applied to a series of 9 Danish adults of known age at death and 11 ancient Danish skulls age-determined by current anthropological (non-dental) methods. A distinct advantage is that this method does not damage the specimens. More work, however, is needed before age determination by the replica method is sufficiently well standardized for general use.

Another promising dental approach to age determination is that indicated by Gustafson of Gothenburgh, Sweden and described in *Odontologisk Tidskrift*, 55: 556-568, 1947. This method is based on a pooled score of age changes as seen in ground sections of teeth. Occlusal attrition, secondary dentin formation, apposition of cementum, apical resorption, parodontal attachment and transparency of root dentin are each classified as degree 1, 2 or 3. The scores obtained from each are added and the age determined from a standard curve (age plotted against total score) valid for the same examiner and ethnic group only. Very good results are obtained, but the method requires sectioning of the teeth and a new base-line study for each examiner and ethnic group.

23. A comparison of certain aspects of body structure and body shape in 200 adults. Earle L. Reynolds, Fels Research Institute for the Study of Human Development, Antioch College, Yellow Springs, Ohio.

Measurements were taken of breadth of fat, muscle and bone, as seen in roentgenograms of the leg in 100 men and 100 women, ages 19 to 70 years. Weight,

height, calf circumference and photographs were also taken. Assessments of androgyny (Bayley and Bayer) were made on selected cases, and somatotypic extremes (Sheldon) were determined.

Men have significantly larger legs, more muscle and bone, and less fat than women. Sex differences in tissue distribution are much more pronounced than in size of leg.

The distribution of tissue breadths in each individual case was examined. Marked deviation in tissue distribution tends to be associated with a deviant body shape. Individuals with a tissue distribution characteristic of the opposite sex have a body shape tending to resemble the opposite sex. There is a close association between the distribution of the fat/bone index (breadth of fat in leg divided by breadth of bone in leg) and masculinity-femininity of body shape, as measured by androgyny scores.

When somatotype extremes are compared, endomorphs are heaviest in weight, with lowest ponderal index, thickest legs, most fat and relatively least muscle and bone. Mesomorphs are intermediate in size, with largest bones and relatively largest muscles. Ectomorphs are lightest in weight, with highest ponderal index and least fat, muscle and bone; they have the relatively thickest bones.

24. *Critical observations on Wood Jones' "Hallmarks of Mankind."* Adolph H. Schultz, Johns Hopkins University.

In disagreement with claims, made recently by Prof. F. Wood Jones, it is shown that: (1) The lower limbs are longer than the upper ones not only in man, but also in a variety of other adult primates. (2) The lacrimal forms a suture with the ethmoid in all Old World monkeys, gibbons and orang-utans, but in only 50% of chimpanzees, 43% of gorillas and 93% of men, according to observations on a total of 957 specimens. Among chimpanzees, gorillas and men the frontal and maxillary meet behind the lacrimal with varying frequencies. These conditions can differ in the right and left orbits of the same skull. (3) The frontals meet each other endocranially behind the ethmoid, separating the latter from the sphenoid, in all catarrhine monkeys (except one baboon) and all gibbons, but this "fronto-basilar suture" is found in only 1% of orang-utans, 23% of chimpanzees, 52% of gorillas, and 3% of men (9% of Negroes only), according to observations on 1,263 specimens, including data from the literature. (4) Certain conditions in the formation of the great toes of higher primates are not as claimed by Prof. Wood Jones.

25. *Dentition of the chimpanzee as compared to man.* E. L. Schuman, Department of Anthropology, Harvard University. (No abstract received.)

26. *Histological studies of ancient and recent teeth with special regard to differential diagnosis between intra-vitam and post-mortem characteristics.* Reidar F. Sognnaes, Harvard School of Dental Medicine, Boston.

Human teeth of prehistoric, ancient, and recent times have been examined grossly and histologically. The histological observations indicate that the most common post-mortem change consists in large irregular canals which penetrate the dentin

and cementum, a condition not known to occur in teeth during life. The microscopical pattern of the post-mortem destruction is most suggestive of an invasion by fungi. Post-mortem changes are rarely found in the enamel and were in this series limited to localized areas of decalcification or erosion of the enamel surface. A few histological landmarks are recorded by which to distinguish *intra-vitam* and post-mortem lesions of the teeth. Post-mortem destructions are indicated by their unusual histological pattern and by the absence of vital reactions in proximity to the defects. Formative abnormalities reflect themselves in the pattern of the incremental growth lines and calcification. Defects arising during function are indicated by a break in the continuity of the incremental contour lines accompanied by certain vital reactions in the underlying dental structures. A histological study of the developmental structure of Greek teeth (obtained through the courtesy of Professor John Coumaris, Athens Anthropological Museum) originating from pre-historic to present times indicates: (1) that no period is characterized by teeth of uniformly perfect structures; and (2) that teeth of recent and present time exhibit more frequently a defective development.

27. Blood type frequencies and distribution in the Puerto Rican population.
Frederick P. Thieme, University of Michigan.

From a controlled representative sample of over 3,000 Puerto Ricans the following island total blood type percentage frequencies were found:

TYPE	FREQUENCY	TYPE	FREQUENCY
O	53.99	rh-	8.74
A ₁	24.83	Rh'	1.22
A ₂	9.61	Rh''	0.47
B	9.52	Rh' Rh''	0.11
A ₁ B	0.98	Rh ₀	13.21
A ₂ B	1.04	Rh ₁	48.93
Total number tested: 3245		Rh ₂	14.79
		Rh ₁ Rh ₂	12.50
		Total number tested: 2528	

When the data were analyzed by racial group and by 15 geographic regions believed to be homogeneous, significant heterogeneity by racial group and by regions was found. Within one of the racial phenotypically homogeneous categories there was significant regional heterogeneity, by the Chi-Square test, in the frequency of Rh blood types. These findings clearly indicate that, in blood group survey studies, the problem of sampling and internal variation in a phenotypically homogeneous population must be considered. It is suggested that many previously reported group differences may well be an artifact of insufficient samples or regional variation rather than true population differences.

The frequencies reported here place the Puerto Rican population intermediate between the White and Negro as found in other studies, which confirms the obvious fact that these two groups predominate in the island. Gradients in gene frequencies between Negro and White were also as expected. A sub-sample of persons with "medium" or "marked" shovel-shaped incisors were not in any respect significantly different in blood type frequencies from the total population.

The testing reported here was performed by the Blood Bank Laboratory of the School of Tropical Medicine and was sponsored by the Social Science Research Center of the University of Puerto Rico.

28. Age changes in head hair from birth to maturity. III. Scale counts of hair of children. Mildred Trotter and Oliver H. Duggins, Department of Anatomy, Washington University, St. Louis.

Scale counts have been studied on head hairs of 16 white children taken from birth to 14 years of age. Series of counts for a given distance along the length of the shaft were made: 100 counts on one hair from each 12-month sample for each individual; two counts on each of 10 hairs, two counts on each of 50 hairs and 50 counts on each of 10 hairs from selected samples. The means of these counts were analyzed statistically in order to determine age variation and individual differences. Results are compared with the findings of Gamble and Kirk (J. Crim. Law and Crim., 31: 627).

An analysis of variance indicates that for the same individual at a given age: scale counts are not homogeneous from hair to hair; the mean obtained by using counts on one hair is not necessarily representative for the total population of hairs; and, a better estimate of the mean is obtained from a few counts on each of 25 to 50 hairs than from many counts on one hair.

There is no significant age change for the group, determined by an analysis of variance in which individual differences are held statistically constant.

A significant individual difference in scale count means is indicated. However, due to the heterogeneity of hairs, it is not possible to identify a child on the basis of scale counts on one hair. A random sample of counts on many hairs would be required to establish identity.

(This investigation was supported, in part, by research grants from the Viking Fund, Inc. and the Division of Research Grants and Fellowships of the National Institute of Health, U. S. Public Health Service.)

29. The analysis of facial growth. S. L. Washburn, Anthropology Department, University of Chicago.

The growth of the face depends on the interrelated action of at least three major groups of anatomical variables: bones, teeth, and muscles. The growth of the bones and eruption of the teeth have been studied frequently, but quantitative descriptions of the growth of the muscles are lacking. A trip to Uganda, sponsored by the Viking Fund, made possible the collection of 100 monkeys. The heads of over 90 were dissected, and the temporal and masseter muscles weighed. A preliminary analysis of these data shows that the muscles play an important role in determining many characters of the adult skull. Temporal fossae, lateral wall of orbits, inter-orbital region, and many crests grow with the muscles. Although adult males and females differ in many characters, it is found that, if skulls from heads of equal muscle size are compared, the crania are nearly identical (except for the size of the canine teeth). It is concluded that no definitive analysis of facial growth is possible unless the muscles are considered.

30. *A summary of present research in Army anthropometry.* Robert M. White, Quartermaster Climatic Research Laboratory, Lawrence, Mass.

Present research in Army anthropometry is summarized and some of the methods currently in use are indicated. Data available for investigation consist of measurements on over 100,000 men and 9,000 women, obtained during an anthropometric survey of Army personnel in 1946, as well as several smaller series measured subsequently. Since one of the primary responsibilities of the Office of The Quartermaster General is to clothe Army men and women, applications of anthropometric data to clothing problems have received first consideration. However, the Army program of research in physical anthropology may be considered to include both basic research and practical applications. Various problems such as age changes, and physical changes resulting from the military environment are being investigated. Since the aim of the Quartermaster corps with respect to clothing is to fit the Army population with the best possible clothing in a minimum number of sizes, requiring the least amount of alteration, the applications of anthropometry to studies of clothing sizes, size systems, and tariffs are particularly useful. Applications of anthropometry to clothing consist of relating body dimensions to clothing sizes. This has necessitated a metric definition of the Army population, together with the establishment of frequency distribution curves for various body measurements. Practical applications of anthropometry and statistics are thus possible in the essentially artistic field of clothing.

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INTERNATIONAL DIRECTORY OF ANTHROPOLOGISTS.—The third edition of this valuable directory has been prepared under the auspices of the Committee on International Relations in Anthropology of the American Anthropological Association and the Division of Anthropology and Psychology, National Research Council, the work being done under the direction of Dr. Melville J. Herskovits. This is presently appearing, and orders for copies not already subscribed for should be addressed to: The Secretary, Division of Anthropology and Psychology, National Research Council, 2101 Constitution Avenue, Washington 25, D. C.

GENETICISTS OFFER \$1,000.00 PRIZE FOR A MATING ISOLATE ESSAY.—The American Genetic Association announces a prize of \$1,000.00 for the best essay written during 1950 in partial answer to the question: "Who marries whom, and why?" The contest is devoted to "delimiting the boundaries of a non-geographical human mating isolate." It is hoped that the contest will clarify some of the social, economic, and educational factors which are important in determining marriage groups.

The size of the group within which marriages are most likely to take place is determined by many factors. On an island in the West Indies, men are more likely to marry girls from the same island than they are girls from Pittsburgh, Pa. The island represents a "geographical mating isolate." But marriage choices are not limited by geography. Going to the same school, working in the same factory, belonging to the same church, tend to create micro-isolates within the borders of a large population. The purpose of this contest is to develop criteria for recognizing such non-geographic factors which to a significant extent limit marriage choices.

Studies made some years ago in North Carolina illuminate this point. In one community studied by Dr. William Allen, church membership constituted a rather clearly defined mating isolate, for in one instance 76% of all marriages were between members of the same congregation.

Prizes totalling \$2,000.00 are offered; the first being \$1,000.00. The contest closes February 28, 1951. The competition is open to all qualified students and specialists in this field. For additional information write the American Genetic Association, 1507 M Street, N. W., Washington 5, D. C.

THE FUNCTIONAL EVALUATION OF ADAPTIVE MORPHOLOGICAL CHARACTERS¹

BOBB SCHAEFFER

American Museum of Natural History

INTRODUCTION

The reality of adaptation and of adaptive trends involving long time intervals has been stressed by all modern authorities on the mechanism of evolution. This reality is based not only on analysis of many examples, both clear-cut and relatively obscure, but also on a thoroughly logical, consistent, and entirely materialistic explanation of how adaptation occurs. The universality of adaptation is becoming so impressive that many characters considered to be nonadaptive or inadapative should be reinvestigated. For instance, the adaptive versus nonadaptive significance of the greatly elongated neural spines of certain pelycosaurian reptiles has been a matter of discussion for many years. Recently Romer ('48) has demonstrated a definite allometric relationship between spine length and body size (as represented by his "orthometric linear unit"). He also convincingly points out that the "sail" supported by these spines probably acted as a heat regulating device; the size of the sail increased disproportionately with body size but proportionately with increase in body volume. E. B. Ford ('49) has stated that a 1% advantage for any character complex can hardly ever be detected, and yet it may be of considerable importance in evolution.

Although a number of experimental studies on the mechanism of adaptation have been made, it is obviously not possible

¹Read at the Viking Fund Symposium on the Evaluation of Taxonomic Characters, University of Chicago, March 4, 1950.

to observe or bring about any major adaptive change in the relatively short time available for such experimentation. Nor can morphologic adaptive trends, often requiring millions of years for their culmination, be adequately appreciated only through a study of selected living organisms. Whenever the data permit, the results of the adaptation mechanism should be considered on the basis of the fossil record. This has been done many times by description and more recently by the addition of quantitative procedures, coupled with interpretation based on modern evolutionary theory.

There is still another tool available for analyzing the evidence of adaptation, which is a consideration of the functional or biomechanical change that accompanies the morphological change. The functional approach, although it has obvious limitations and is not always applicable, does possess certain merit. It introduces a dynamic factor into the evaluation of adaptive change, thereby decreasing the tendency to regard the trend as a series of more or less isolated morphological stages. It focuses attention on the possibility of continuous adaptation by inducing a more penetrating analysis of the morphological change and by suggesting the nature of unknown stages in the adaptive trend.

The combined morphological and functional consideration of adaptational change should, in theory at least, provide the most thorough analysis possible of the animal side of the organism-environment interrelationship. Even so, only relatively gross morphological and functional change can ordinarily be studied or even recognized. This is even more apparent when the fragmentary paleontological data are considered. Furthermore, there are at least practical barriers preventing study of the organism as a functional whole. The usual procedure is to consider character complexes, such as the dentition in mammals or the skull roof in fishes. The adaptation of a particular complex is often not clear in terms of the economy of the entire animal, as, for instance, foot structure in a group of aberrant perissodactyls, the chalicotheres.

THE ANALYSIS OF ADAPTATION

Adaptation has been broadly defined as a state of harmony or close functional interrelationship between the organism and the environment. The extent of this interrelationship is, of course, highly variable and is therefore not an all-or-none phenomenon. Simpson has pointed out that the measure of adaptation is its usefulness under the particular conditions in which the organism lives. Usefulness, in terms of bio-mechanical principles, may be gauged on the basis of functional efficiency, provided the function is determinable and some measure of efficiency can be devised. Herein lies one of the potentially important contributions from the functional analysis of adaptive change in morphology.

In recent years adaptation has been investigated from four interrelated points of view. These may be broadly designated as: (1) the genetic, which has provided some direct experimental evidence on the mechanism involved; (2) the theoretical, which has explained adaptation in terms of a statistical analysis of gene frequencies and how these frequencies are affected by such factors as mutation and selection pressure and population structure; (3) the ecological, which has evaluated adaptation on the broad level of the animal-environment interrelationship; and finally, (4) the historical, which has attempted to analyze the phenotypic expressions of the adaptational process, whether they be physiological or morphological, in terms of the experimental and theoretical conclusions.

In the strict sense, the historical consideration of adaptation properly includes only an analysis of evolutionary change through time, although the possible origin of an adaptation may profitably be studied on the basis of a series of living organisms, selected to represent successive structural stages in the trend. The use of paleontological data gives the time dimension reality, while in its absence time can only be inferred and not actually employed. Both these approaches have certain obvious advantages and both may be regarded as historical only in the sense that they are concerned with

apparent sequences of structural change, whether based on stratigraphic occurrence or on a more subjective selection of contemporaneous types. It might be stated here that the subsequent remarks are based mainly on a consideration of the mammals, although in a more restricted sense they will apply to other vertebrates as well.

Vertebrate paleontologists including paleoanthropologists are essentially limited to the study of a single morphological system — the skeletal, and its rate and pattern of change in time. Davis ('49) has pointed out that the data of paleontology permit only a very indirect approach to the demonstration of adaptation, mainly on the basis that "morphological specialization denotes adaptation." He notes, for instance, that the living horse is highly specialized for a known adaptive zone and that the horse lineage shows progressive change in the direction of this zone. In view of this, it is concluded that the history of this group is one of increasing adaptation. Since the organism-environment relationship that is adaptation can be thoroughly investigated only in living animals, he logically points out that for fossil groups without living representatives, paleontologists can never study the apparent adaptation directly, but only through analogy with more or less distantly related living types. It is evident, therefore, that the paleontologist and the paleoanthropologist, working under this handicap, must utilize the skeleton to the best possible advantage and also pay attention to whatever paleoecological data are available.

The practical problem of how to arrive at some measure of adaptation in terms of usefulness or in terms of functional efficiency is almost as complicated as the problem of explaining the mechanism of adaptation. It is the animal as a functional whole that has attained equilibrium with the environment, not just a single morphological system or functional subdivision. The question therefore arises: if adaptation involves the organism as a unit, and all the morphological systems are physiologically and structurally integrated to form this unit, is it valid to consider the skeletal system as

an adequate sample of the whole? The answer is probably "no" for low taxonomic units, but it may be a *qualified* "yes" for higher ones. It is perhaps a safe generalization to state that the longer an adaptational trend has been under way, the greater the opportunity (which may, of course, not be realized) for it to influence, in some observable fashion, the skeleton. Besides revealing even relatively minor adaptive changes within itself, this system will provide concrete evidence on changes in diet, in brain form, and less certainly in some features of the soft anatomy. Differential rates of evolution affect, in general, regions of the body rather than morphological systems, and they are often revealed in the skeleton. The degree of adaptation can rarely, if ever, be measured or expressed on an absolute basis, certainly never when paleontological data are involved; it can only be measured in a relative sense. Thus it can be stated that population A is in certain respects more specialized than population B; and this difference may, if the data permit, be expressed in quantitative terms.

It is obvious that any evaluation of functional and morphological adaptation should include consideration of living and fossil animals whenever this is possible. This can be accomplished, to a greater or lesser degree, at all taxonomic levels. At higher levels, where the adaptive zone is broad, the analysis will be necessarily more general and more basic. Deductions based on fossil material, derived in turn from consideration of living descendants or close living functional counterparts, will be correspondingly more valid. For instance, a thorough biomechanical analysis of the primitive tetrapod skeleton should be essentially an analysis at the class level. The basic problems involved are common to most members of the class Amphibia (excluding the limbless types), and for this reason both the labyrinthodonts and the living terrestrial caudate Amphibia will supply important data.

By way of contrast, the analysis of adaptive trends at the generic or the specific level, such as the evolution of a grazing

dentition in horses, requires a closely graded fossil lineage for the time interval involved. The functional aspect of this particular trend would necessarily start with the living *Equus*.

THE FUNCTIONAL APPROACH

The functional analysis of adaptive change is still very much in its infancy. Various techniques and methods are available for this purpose, mostly from the study of human biomechanics, and many of these are of more or less general application. Gray ('44) has made an important but largely theoretical study on the mechanics of the tetrapod skeleton. The recent paper by Slijper ('46) on the biomechanics of the vertebral column in mammals contains analytical procedures that may validly be applied to all types of vertebrates, fossil and recent. It represents a well-considered balance between morphological and functional interpretation, but with only minor consideration of evolutionary and taxonomic implications.

In a consideration of morphologic adaptation it is important to distinguish between character complexes that are primarily affected by selection and those that are secondarily modified, apparently in response to the primary adaptation. The dependent modification may occur coincidently with the basic adaptational change, or it may lag until some functional threshold is passed. The relationship between the primary and one or more dependent changes may be an obviously intimate one, or it may appear remote and poorly defined. Furthermore, in closely related forms the dependent modification may, while still serving the same function, be subject to much greater variation than the primary adaptation. In bony fishes the jaw mechanism shows a number of marked adaptive modifications, and these have all had a secondary influence on the pattern of the cheek region (see, for example, Rayner, '41). The pattern may be strikingly different in various species of the same genus and possibly at even lower taxonomic levels. Adaptive changes in the jaws and dentition of the various primates have influenced the architecture of

the skull, particularly in the facial region, and these primary and secondary differences are even evident in some males and females of the same species. The relationship between the primary morphologic adaptation and the consequent secondary affects can be fully appreciated only when functional analysis is possible.

All parts of the vertebrate organism are potentially susceptible to functional analysis. Since the only morphological system that can be studied in common by the paleontologist and the neozoologist is the skeleton, it is of interest to consider briefly in what manner this system lends itself to biomechanical investigation. Certain of the more basic problems, especially as they pertain to the mammals, may be listed as follows:

Skull. The skull is perhaps the most difficult part of the skeleton to analyze functionally and consequently has been the most neglected. One of the more fundamental problems is the relationship between adaptive change in the dentition, jaws, and associated musculature, and the influence of this change on skull architecture. The method utilized by Benninghof ('25) and his followers (Henckel, '31) for determining patterns of force distribution in the mammalian skull represents one attempt in this direction. It should, however, be applied more widely and also be subjected to experimental evaluation. Once the relationship between the force distribution pattern and skull form has been determined for a number of different skull types, fossil skulls can perhaps be interpreted on this basis with the probability of only minor error. The experimental techniques employed by Washburn ('46a, '46b) are likewise of importance in the functional evaluation of the skull. The relationship between gross changes in brain form and skull architecture, the mechanics of jaw motion and of skull suspension all need further elucidation.

Vertebral column. Slijper ('46) has rather thoroughly summarized previous work on the biomechanics of the vertebral column. Methods are discussed for evaluating the angulation and size of the neural spines, the resistance movements of the

vertebral bodies, and the total and regional mobility of the column. Much of this can be applied directly to fossil materials, and it should be of importance in analyzing locomotor trends and problems of body support.

Appendicular skeleton. In many respects the appendicular skeleton offers the greatest possibility for the functional analysis of adaptive change. The relationship between joint structure and joint motion can be investigated in some detail in fossil as well as living animals (Schaeffer, '47). Changes in the relative length of limb segments, in their angulation, and in their cross-sectional area, will provide data on locomotion and relative body weight and indicate shifts in the center of gravity.

The dynamic aspects of adaptation are complex and difficult to investigate under the most favorable conditions. The methods by which animals obtain and masticate their food, as well as the ways in which they move, are important general aspects of this broad topic. The above brief but representative list of biomechanical problems involves consideration of these topics and indicates that they can be specifically investigated from a functional point of view in fossil as well as recent animals. The degree to which this can be accomplished will depend on the susceptibility of the particular character complexes to biomechanical analysis and also on the existence, for fossil forms, of a living descendent or close living functional counterpart.

Evaluation of an evolutionary trend may involve not only an analysis of the morphological and functional change as such, but also, by employing these data either directly or through their taxonomic implications, a consideration of evolutionary rate and mode. Functional data may be employed statistically in the same manner as morphological, in determining rate, and may have the added advantage of representing in a single unit a number of purely morphological entities. For instance, the size of an angle between two joint axes can express a relationship that would be very difficult to state by simple measurement of the bones involved.

Thus evolutionary rate may presumably be determined by plotting functional data for different time levels — either against other such data or directly against time. To my knowledge this has not been attempted and in actual practice may involve more than a justifiable amount of labor.

Functional analysis may provide supporting evidence regarding the pattern of evolution involved in the origin of a particular character complex or group of complexes. It can at least increase or decrease the probability that a given evolutionary trend was characterized by continuous adaptation throughout its duration, or that it suffered one or more periods of adaptational instability. The final conclusions are, of course, of great importance in evaluating the nature of the evolutionary mode involved in the trend.

In terms of function an adaptive trend is theoretically terminated when the biomechanical limit (Huxley, '42) of specialization is attained. Although the structure-function relationship may be very inefficient from a purely mechanical point of view, it must be efficient enough to meet the demands of the environment at any time level during the trend. The biomechanical limit represents that stage in an adaptive trend at which a particular character complex has attained the greatest possible mechanical efficiency and therefore undergoes no further adaptive change. The only available clue that the limit has been approached for a particular structural and functional unit is the simple observation that it has remained essentially unchanged throughout a considerable time interval, during which other parts of the skeleton have, in turn, become progressively adapted for the same general habitus and in response to the same selective factors.

Very few attempts have been made to analyze adaptive morphological change on the basis of both structure and function. An excellent example of this approach is the work of Camp and Smith ('42) on the phylogeny and function of the digital ligaments in horses. By the *Merychippus* stage in the evolution of the forefoot, there was a marked increase in the number and complexity of the sesamoidean ligaments

of the foot. This change was apparently correlated with an almost complete transformation of the interosseus medius muscle (running between the enlarged third metacarpal and the sesamoid at the metacarpal-phalangeal joint) into a powerful elastic tendon. In addition, a new ligament tied the elastic tendon to the second phalanx by running between that bone and the sesamoid. The support of the second phalanx by the straight ligament implies that this phalanx was no longer adequately supported by the probably reduced plantar pad, which was presumably much larger in *Hyracotherium* and *Mesohippus*. These modifications thus provided for the first time in the evolution of the foot a mechanism for automatic elastic springing of the distal portion of the foot; as the pressure of the body on the foot was reduced toward the end of the propulsion phase, the rapid contraction of the tendon assisted in propelling the body forward. The action of the spring tendon was analyzed experimentally in the modern horse. Between *Merychippus* and *Equus* the number of sesamoidean ligaments was slightly reduced; but with the increase in body weight and the great reduction of the side toes, the remaining tendons, including the spring tendon, increased in size and consequently in functional efficiency.

Robb ('36) has demonstrated that the 2nd and 4th digits show a slightly negative allometric relationship with the cannon bone in both the functional three-toed and the functional one-toed horses. The constant b of the allometric formula ($\log y = \log b + k \log x$) is, however, only half as large in the one-toed forms, although the constant k remains about the same. Simpson points out that this change in the value of b , which must have occurred between *Merychippus* and *Pliohippus*, involved a definite genetic change. If the opinion is correct that a constant allometric relationship in time results from a single genetic rate determinate, then it may be assumed that the character complex involved has undergone no adaptive evolution since the establishment of the relationship. Changes in the proportions of the com-

ponents of such a complex simply result from the various sizes attained by the adult animals. At one stage in the evolution of the horse foot, however, there was genetic change which resulted in a rapid alteration of toe proportions and associated structures, *independently* of any change in body size as a whole.

There is thus evidence from two sources that the stage in foot evolution represented by *Merychippus*, or by some undescribed transitional types between *Merychippus* and *Pliohippus*, was a critical one. The implication of the ligament study is that this stage was not one of functional or morphological inadaptation. It may, however, be regarded as a threshold in the sense that the foot was no longer structurally or functionally adapted to the precursorial zone of *Hyracotherium* and *Mesohippus*, nor perfectly adapted for the cursorial zone of *Pliohippus* and *Equus*. It was preadapted for the cursorial zone but at the same time was adapted to the conditions of the transitional zone. The transition occurred in a relatively short period of geologic time. In regard to the mode involved during the shift, it was essentially phyletic, as defined by Simpson ('44). In a general way the pattern of this transition suggests Simpson's ('44) analysis of the change from a browsing to a grazing dentition in horses or Patterson's ('49) description of an adaptive shift in taeniodont evolution.

In the example just discussed, the relative abundance of material for nearly all time levels throughout the Tertiary permitted consideration of adaptive change at the generic level (variation at the specific level was also taken into account by both Camp and Simpson). Several years ago the writer ('47, '48) attempted to analyze an adaptive trend which resulted in the origin of an ordinal character. The character or, more correctly, the character complex chosen was the artiodactyl tarsus. There is now little doubt that the artiodactyls arose from a group of primitive ungulates called condylarths. The early members of one condylarth family had a dentition that bears a detailed resemblance to

the basic artiodactyl type. An examination of the tarsal characteristics in these forms showed very close agreement with the primitive condylarth tarsus in general and, in fact, with the tarsus of the condylarth ancestors, the earliest creodont carnivores. It thus became obvious that the origin of the highly characteristic artiodactyl tarsus involved a transition from the basic creodont-condylarth type to the artiodactyl type. The transition occurred in not more than 17 million years (the estimated duration of the Paleocene.). For this period transitional stages are unknown or are, at least, not recognized if they do exist in collections.

The axes of rotation of the principal tarsal joints were determined and tested for a representative of the creodont-condylarth type and for an artiodactyl. The joint function was analyzed and an attempt made to evaluate the mechanics of tarsal movement in each.

The results indicate that the transition was one of continuous adaptation, that no apparent threshold effect was involved, and that the biomechanical limit for the artiodactyl tarsal structure was essentially attained by the early Eocene. The evolutionary mode involved was again essentially phyletic. In terms of the tarsal patterns of known terrestrial mammals, the transition was a radical one and clearly involved the attainment of a new adaptive zone. The transformation in the digital portion of the horse foot, and that leading to the artiodactyl tarsus, represent different degrees of morphological and functional change associated with the development of highly efficient cursorial mechanisms. In both cases the principal selective factor was probably predator pressure, supplied by the contemporaneous and rapidly evolving carnivores.

CONCLUSIONS

The functional evaluation of adaptive trends in character complexes involving the skeleton will provide additional information on the mode of origin and on the significance of such adaptations in terms of the animal as a functional whole, and in terms of the environment. The detail in which this

can be accomplished will depend mainly on two factors: the susceptibility of the complex to functional analysis in living representatives or apparent functional counterparts, and the completeness of the paleontological record.

The relative abundance of knowledge on Recent primate morphology, plus the fact that this order includes the only vertebrate (man) that has been subjected to a reasonably complete biomechanical analysis, places the primates in a favored position for functional analysis of adaptive trends. The known fossil record for the entire order from the Paleocene to Recent has many serious deficiencies. It is based to a large extent on skulls that are often incomplete, or simply on parts of the dentition; reasonably complete skeletons are indeed rare. In spite of this defect, it should be possible to consider the functional implications of a number of adaptive trends, at various taxonomic levels, in both the skull and post-cranial skeleton.

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KNOWLEDGE IS POWER.—One day a farmer found a bone; he thought at first it was a stone, and threw it at a passing snake ere he discovered his mistake. But when he knew it was a bone, and not a diamond or a stone, he took it to an ancient sage, who said: "In prehistoric age, this was the shin-bone of a Thor-dineriomegantosaur-megopiumper-mastodon-letheriumsohelpmejohn." The farmer cried: "Dad bing my eyes! Was ever man so wondrous wise? He gazes on a piece of bone, that I supposed to be a stone, and, with a confidence sublime, he looks across the void of time, and gives this fossil bone a name, the fragment of some creature's frame! To have such knowledge, sir, as thine, I'd give those fertile farms of mine." "Don't envy me," the sage replied, and shook his weary head, and sighed, "Your life to me seems full and sweet — you always have enough to eat!" Uncle Walt, by Walt Mason, Chicago, 1910.

NOTE ON THE SKULL OF THE SWARTKRANS
APE-MAN PARANTHROPUS
CRASSIDENS

R. BROOM AND J. T. ROBINSON

Transvaal Museum, Pretoria, South Africa

SIX FIGURES

We have found the deposit at Swartkrans, in the Krugersdorp district of the Transvaal, to be very rich. In 13 months' work we have discovered of the large ape-man 5 lower jaws and 4 faces with palates. We have a couple of adult skulls hopelessly crushed, and the skull of a child of about 7 years considerably crushed but excellent, and we have over 150 teeth — many in superb condition. We also have a few bones of the hand and arm. Unfortunately we have no good brain case except the crushed child skull; but we can make some estimate of the adult size.

One of the early discoveries made by the junior author when the senior author was in America in 1949 was a massive lower jaw. Apart from the right ascending ramus it is nearly complete and only a little crushed. In plate 2 we give a true side view of the left side. Part of the angle and much of the coronoid process are restored, but from what is preserved the restoration can be confidently made. Though the condyle is lost this also can be satisfactorily restored as we have most of its base preserved.

The jaw is really huge (see plate 1). The direct measurement from the condyle to the front of the chin is 165 mm. In the Heidelberg jaw the corresponding measurement (made on the cast) is 140 mm and in the jaw of a large male Bantu 135 mm. In one of the Wadjak skulls the measurement (made on the cast) is 143 mm. The only human or prehuman jaw

that we know of which is possibly a little larger than this Swartkrans jaw is the imperfect one from Java described by von Koenigswald as *Meganthropus palaeojavanicus*. Of course *Gigantopithecus blacki*, known only by three teeth, whether ape, ape-man or human, must have been really much larger.

Having the practically perfect jaw and a considerable part of the face we can form some idea of the size of the brain.

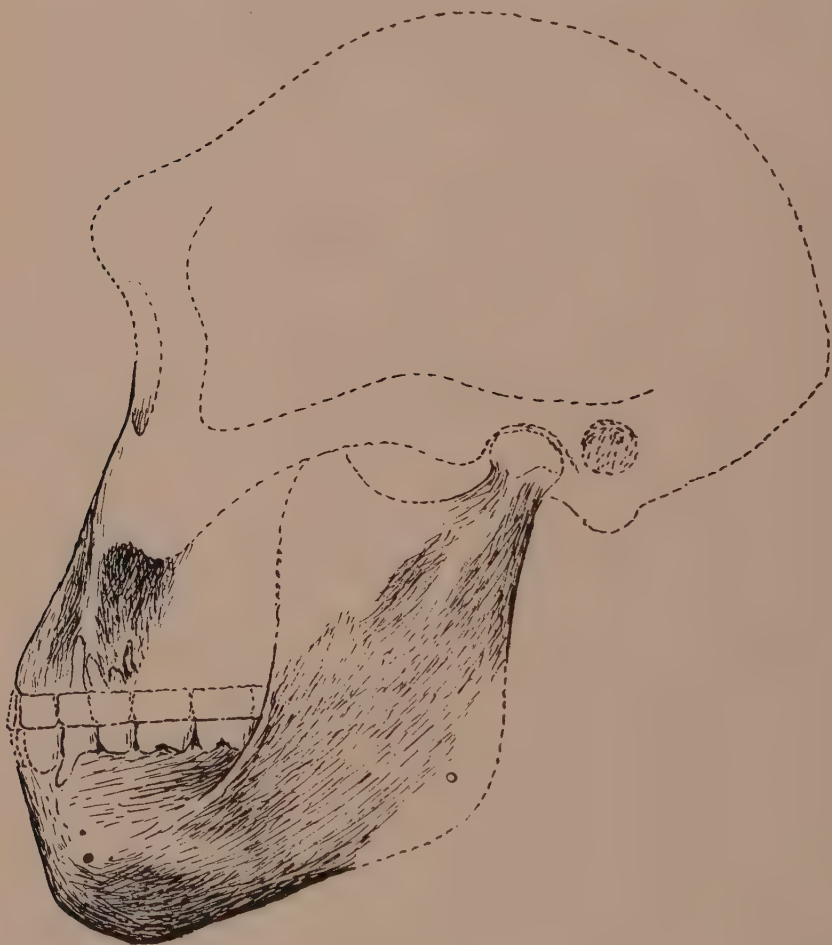


Fig. 1 Side view of skull of male Swartkrans ape-man, *Paranthropus crassidens*, restored from jaw and face. Two-thirds natural size.

We have four definite guides to the shape and size of the base of the skull. We know the position of the two glenoid cavities and the bases of the two orbits.

In the drawing which we give of the side view of the skull as we restore it, the positions of the orbit and the glenoid fossa are certain; the rest of the cranium is restored. We have restored the back part of the skull from what we know of the allied *Paranthropus robustus*. The less closely allied *Australopithecus* and *Plesianthropus* have aided us in the restoration of the brain case. Of course we also have the crushed brain case of the child.

It will be readily understood that it will take months to publish full accounts of all the material we have discovered. Besides the memoir on "The South African Fossil Ape-men — The Australopithecinae" published in 1946, the second memoir, "The Sterkfontein Ape-man *Plesianthropus*" has just been published (April, '50) by Broom, Robinson and Schepers. We already have a third memoir in hand with much work done on the Swartkrans Ape-man, but this is not likely to be ready for over a year. Even if we may be criticised on the grounds of publishing inadequate descriptions, we do feel that advance notes on some of the more important finds serve a valuable purpose.

Other scientists can make restorations of the braincase to suit their views; but we do not think our restoration can be very far wrong. As we restore it the length of the skull from the glabella to the occiput is about 180 mm. The width of the skull must be less sure. The measurement across the two condyles of the jaw is about 135 mm and we do not think it can be less than this. But as the two jaws are slightly crushed together and the right ascending ramus lost, the exact width cannot be given to a couple of millimeters. It is improbable that there is an error of more than 5 mm. In man and the apes the brain case is approximately equal in width to the measurement across the condyles. In man it is frequently a little wider. We are probably safe in assuming that the brain case in this Swartkrans skull had a width of about 130 mm.

If these measurements are approximately correct, then we have a skull with a length and breadth of about 180 mm and 130 mm — measurements which are frequently met with in human skulls. Of course the shape of the top of the skull probably differed considerably from that of modern man. Most likely, as in the *Plesianthropus* skull, there was a considerable supraorbital ridge, possibly even larger than we make it. We do not know the height of the vault. In *Paranthropus robustus* the brain case must have been fairly high, from what we have preserved of the parietal.

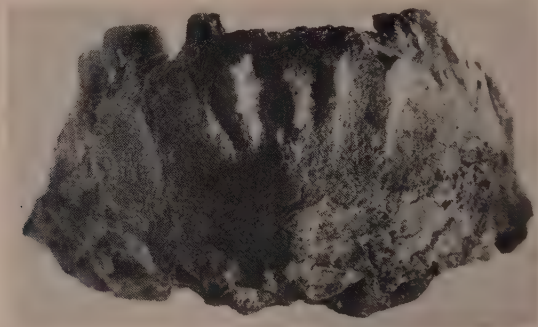


Fig. 2 Front view of chin of female *Paranthropus crassidens*. Natural size.

We have reconstructed a brain to fit our restored skull, making allowance for a considerable supraorbital ridge and a skull wall of moderate thickness. Our restored brain, we find, measures 980 cm³ in volume — closely similar in size to the brain of the first *Pithecanthropus erectus* skull. The top of the skull may be flatter than in our restoration and the brain case may be a bit shorter or narrower than we make it, but we do not see how it can have a volume of less than 850 cm³ and think it likely to be well over 900 cm³. Even the 7-year-old child skull seems to have a width of at least 110 mm and a length of about 160 mm and we think it likely to have a brain of well over 600 cm³ — perhaps 650 cm³.

If size of brain is to be the main criterion for distinguishing ape and man we think the Swartkrans male being can put

in a claim to be considered as possibly man, even if his female with a brain of 700 cm³ must be considered an ape.

We have an interesting jaw of a female (figs. 2, 3 and 4). Unfortunately it is imperfect, but it has most of the symphysis well preserved and it has a very distinct chin. Heidelberg man has no real chin. The front of the symphyseal region has 6 rather marked ridges running down over the roots of the incisors and canines. For 15 mm below the alveolar margin, the median section has its front border passing downward and slightly backward. Then it curves forward and

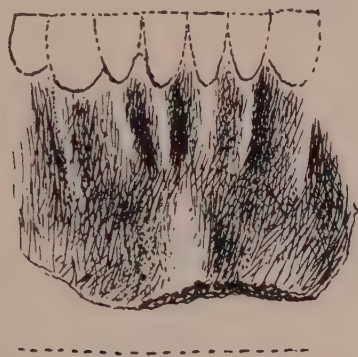


Fig. 3 Same as figure 2; diagram to show probable restored height and teeth.

in the middle line there is a marked boss or mental protuberance such as is seen in most Bushmen and in many other human jaws. Below this boss the front of the chin curves downward and backward, but unfortunately the lower portion of the symphysis is lost. There is an indication of a mental tubercle at the sides, but it is not satisfactorily preserved.

On the inside of the jaw the whole symphyseal region is perfect except for the lower quarter (see fig. 4). Behind the incisors there is a deep hollow such as is rarely seen in apes or man. The whole symphysis is very wide in the region of the chin protuberance, being 25 mm at this part. Then below the back of this transverse ridge there is a slight hollow forming the genial fossa. Below this the symphysis is gone but was probably as we restore it. We cannot say if there

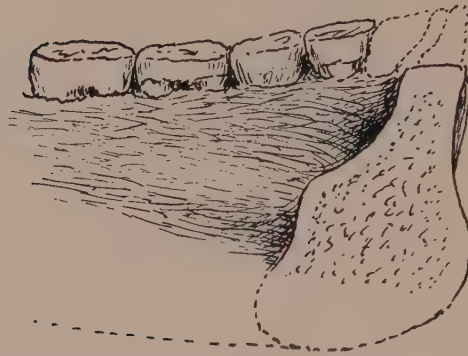


Fig. 4 Inner view of left side of lower jaw of female *Paranthropus crassidens*, to show median section of symphysis, partly restored. Natural size.

was a simian shelf but most probably there was not as there is no trace of a shelf in the other jaws which have this region preserved.

It is very interesting to find in this jaw of a female Swartkrans ape-man a mental protuberance not unlike that found in Bushmen, while there is no protuberance in Heidelberg man. There is also some indication of lateral mental tubercles similar to those seen in Bush, Australian and most other human skulls. So, though the back part of the symphysis is not typically human and a little like the condition seen in the Heidelberg jaw, perhaps the female Swartkrans being—even if her brain may be only 700 cm^3 in volume—may be able to put in a claim for human status by virtue of her having a human chin.

PLATES



Occlusal view of lower jaw of large male *Paranthropus crassidens*, photographed at right angles to plane of horizontal ramus. Natural size.



Oclusal view of lower jaw of large male *Paranthropus crassidens*, as preserved but with coronoid process and left condyle restored, photographed at right angles to the main plane of the jaw. Natural size.



CALCULATION OF STATURE FROM LONG BONES.—Telkkä, of Helsinki University, has investigated the relationship between the length of the long bones and corpse length in Finns, in order to derive formulae for the prediction of stature in this group. (Telkkä, Antti. On the Prediction of Human Stature from the Long Bones, *Acta Anatomica* [Basle] IX: 103–117, 1950.)

Starting with 154 skeletons (115 males and 39 females) he has correlated corpse length with the length of all 6 long bones. The highest correlations with stature were given by the fibula in the male (+ 0.73) and the humerus in the female (+ 0.74). The differences between the lowest and the highest values were not significant, and he concludes that “no bone can be given definite preference in this respect.”

Telkkä has set up prediction formulae of the general form, using the mean stature as a constant. Of general interest are the formulae for prediction of stature (S) from the femur (f) for males and females which are:

$$S = 169.4 + 2.1 (f - 45.5) \pm 4.9 \text{ cm, and}$$

$$S = 156.8 + 1.8 (f - 41.8) \pm 4.0 \text{ cm, respectively}$$

Of necessity, such prediction formulae are most inaccurate with extreme values, as the author states.

Despite racial differences in the original material, statures computed by Telkkä's method closely correspond to calculations by Pearson's formulae. Using the same bone lengths as a starting point, Breiting's method and Manouvrier's method diverge from the former two. It is instructive to see how various methods yield markedly different estimates of stature. Telkkä has calculated tables of stature corresponding to various bone lengths as a further aid to field workers.

With measures of prediction, especially those based on correlation coefficients lower than 0.9, it is important to know how close the predicted value is likely to come to the true value, and how large the standard error of the estimate is in comparison to the variability of the population. Telkkä gives a standard error of the estimate of about ± 4.5 cm, and a standard deviation for mean stature (in males) of 6.5 cm. Therefore, Telkkä's method reduces variance by about one-half.

ON THREE SKULLS FROM MECHTA-EL-ARBI, ALGERIA. A REEXAMINATION OF COLE'S ADULT SERIES

L. CABOT BRIGGS

American School of Prehistoric Research (Director of Studies in Algeria)

SIX FIGURES

INTRODUCTION

The three skulls described below were excavated in the escargotièrre of Mechta-el-'Arbi, Department of Constantine, Algeria, in 1927 by Dr. Paul H. Nesbitt, at that time acting chief of an expedition sent out by the Logan Museum of Beloit College. The industrial context was Upper Capsian.

The skulls were restored at the University of Chicago, and a study of them, including photographs and a few measurements, was published by Dr. Fay-Cooper Cole ('28) as a supplement to the general excavation report by Alonzo W. Pond. Eventually the skulls were returned to Algeria, where they disappeared into the storage space of the Bardo Museum (Algiers).

In 1949 a number of unlabelled skulls were turned over by Mr. Maurice Reygasse, Director of the Bardo, to the laboratory which had just been established in that Museum by Mr. Lionel Balout, Professor of Prehistory at the University of Algiers. This material had suffered due to having been buried for safety during the war, and several identifying labels had been lost or destroyed by silver fish. The three skulls in question were in a separate tray that contained nothing else except some tiny scraps of old newspaper, on two bits of which we were able to decipher parts of the words "Beloit" and "Wisconsin." A quick glance at Cole's plates and a check with the calipers settled the problem of identity.

The skulls had suffered some breakage, and so I was entrusted with the task of putting them in presentable shape. While doing so I discovered that the original restorations were far from satisfactory. The materials used were plaster of Paris, a kind of hard, tough putty, and furniture glue. These had been introduced between the contact surfaces so that the true dimensions were increased and proportions distorted. Cole himself ('28, p. 181) says of no. 3: "Coronal and sagittal sutures somewhat obscured by restoration . . ." In some places where the outer surfaces of joins were not smooth they had been rounded off with a coarse file. In view of all this I decided to leave no. 1 as it was (its fragmentary state and extreme *post mortem* deformation made it hopeless to think of getting worthwhile measurements), but to take nos. 2 and 3 entirely apart and start over.

As my morphological observations and conclusions regarding this series will appear *in extenso* elsewhere (Briggs, '50), I will give here only a brief summary of them, omitting such details as are apparent from the accompanying tables and plates. The photographs reproduced in the plates were most courteously provided by the Laboratory of the Bardo, of which Mr. Balout is in charge. I take this opportunity of expressing my most sincere thanks for his tireless cooperation.

MORPHOLOGICAL DESCRIPTIONS

No. 1. All that is left of this skull is the *calvaria* (minus the right side and the base) and the mandible. Age at death was probably 25 or under. Although Cole classified it as male, I am inclined to consider it female in the light of the Afalou series (Arambourg, Boule, Vallois and Verneau, '34) which was excavated after Cole's article appeared. It is a heavy, massive skull that fits well enough into the morphological category of the Mechta-Afalou type (Briggs, '49). The mandible has been greatly modified by extensive abscesses which, however, healed well for the most part. The gonial angles are turned outward. The lower incisors were removed by tooth knocking, and the alveolar margins that contained them are

completely absorbed. The dental arch was parabolic. Tooth wear is extreme, but there is no pyorrhea or caries.

No. 2. It appears that the object of the first restoration of this skull was to reestablish the *in vita* form, a hopeless proposition in view of the extent and degree of *post mortem* deformation. My reconstruction is an attempt to present it as it must have appeared *in situ* to the excavators.

At death the subject seems to have been about 30. Cole considered this skull male: I would certainly not hazard any opinion beyond noting that, compared with the Afalou series, it seems perhaps rather more effeminate than otherwise. (The supposition that nos. 1 and 2 may well be female is perhaps strengthened by the fact that two or three foetuses were also found in the course of the excavations, although their position in relation to the adult skeletons has never been described [Cole, '28, p. 167 and Debruge, '28, p. 61].)

Once again the skull is heavy and massive, and appears from what is left of it to fit well enough into the Mechta-Afalou category. Of the face almost nothing remains, but we note that the nasal sills are smoothly rounded, and that the two central and the second left upper incisors were removed by tooth knocking. The upper jaw is a mass of frightful abscesses which caused the loss of most of the teeth, and which remained active or imperfectly healed for the most part, although they are not remarkably deep.

The mandible again is very shallow, except in the symphy-sial region, due to abscesses that probably caused the loss of all the molars, but healed well. The gonial angles are very flaring. The chin is very square and projecting, the sub-alveolar constriction is pronounced, and the crowns of the front teeth rise in an inverted V into the gap left by the evulsion of the upper incisors. Only the left condyle remains, its top eroded and ringed with a fringe of arthritic exostosis. Tooth wear is very marked, and there is some pyorrhea but no caries.

Only two lower incisors are present, and it appears that the other two never erupted, but this is more probably due to evulsion at an early age. Cole raised the point, which remains doubtful, that some of the molars may never have erupted.

TABLE 1

Available measurements of the Mechta-el-Arbi skulls

MEASUREMENTS ¹	NO. 1	NO. 2	NO. 3
Cranial length	?	187 (?)	182
Glabella-inion l.	?	?	180
Cranial breadth	?	?	132
Biasterionic br.	?	105 (??)	99 (?)
Auricular height	?	?	116 (?)
Min. frontal br.	?	?	95
Max. frontal br.	?	?	110
Horizontal circum.	?	?	497 (?)
Sagittal arc	?	?	372 (??)
Frontal arc	?	?	117
Parietal arc	?	130	125
Occipital arc	?	?	132 (??)
Transverse arc	?	304 (??)	310 (??)
Frontal chord	?	?	103
Glab.-breg. chord	?	112 (??)	97
Parietal chord	?	115	112
Breg.-inion chord	?	?	155
Occipital chord	?	?	107 (??)
Left parietal thick.	6	5	4 +
Schwalbe's bregmatic angle ²	?	?	59.5°
Frontal angle ³	?	?	60°
Capacity (calculated)	?	?	1324
Bizygomatic breadth	?	?	132 (??)
Total face height	?	?	101
Upper face height ⁴	?	?	60 (??)
Nose height	?	?	47
Nose breadth	?	?	28
Upper nasalia br.	?	?	14 (??)
Lower nasalia br.	?	?	21
Left orbit height	?	?	28
Left orbit breadth ⁵	?	?	36 (??)
Right orbit breadth	?	?	36 (??)
Interorbital br.	?	?	29 (??)
Biorbital breadth	?	?	99 (?)
Midfacial angle	?	?	90° (??)
Ext. palate br.	?	?	64 (??)
Condyl-symph. length	96 (??)	100 (??)	101 (?)
Bicondylar breadth	120 (??)	?	114 (?)
Bigonial breadth	105 (??)	?	89
Symphysis ht. mandible	?	34	30 (??)
Mandible ht. at M1-M2	?	?	27
Mandible thick. at M1-M2	?	?	15
Mandible ht. at nutr. for.	?	?	29
Mandible thick. at nutr. for.	?	?	13
Minimum br. asc. ramus	32	33	36
Mandibular ramus angle	118° (??)	120° (??)	111°
Mand. symph. angle	?	80°	75° (??)
Age	25 —	30 ±	20-25
Sex	♀ (??)	♀ (??)	♀

TABLE 1 — (continued)

MEASUREMENTS ¹	NO. 1	NO. 2	NO. 3
Cranial index	?	?	72.53 (?)
Length-auric. ht. index	?	?	63.19 (?)
Breadth-auric. ht. index	?	?	87.13 (?)
Fronto-parietal index	?	?	71.97
Transverse frontal index	?	?	86.36 (?)
Cranio-facial index	?	?	100.00 (??)
Zygo-frontal index	?	?	71.97 (??)
Fronto-gonial index	?	?	93.68
Zygo-gonial index	?	?	67.42 (??)
Facial index	?	?	76.52 (??)
Upper facial index	?	?	45.45 (??)
Nasal index	?	?	59.57
Left orbital index	?	?	77.78 (??)
Interorbital index	?	?	29.29 (??)
Mandib. length-br. index	80.00 (??)	?	88.60 (?)
Condyl-gonial index	87.50 (??)	?	78.07 (?)
Mandibular robust. index:			
at M1-M2	?	?	55.56
at nutr. for.	?	?	48.28

¹ Figure followed by (?) are approximate because of *post mortem* deformation; those followed by (??) are estimated in the absence of missing parts. In cases where a measurement could not even be estimated with a hope of reasonable accuracy the fact is indicated by an interrogation point.

² Schwalbe's bregmatic angle is the angle between the chords bregma-glabella and glabella-inion.

³ Frontal angle is that between the frontal chord projected and the Frankfurt Plane.

⁴ Upper facial height was measured to the estimated alveolar point corrected to compensate for evulsion.

⁵ Orbital and interorbital breadths were taken to the estimated position of daeryon.

No. 3. The first restoration of this skull was very faulty, in the same manner as the others of the series. In particular, the face had been twisted backward and to the left, increasing considerably the height of the right orbit and the breadth of the left one, and changing the whole aspect of the facial region.

The age at death appears to have been around 20-25. There can be scarcely any doubt in this case that we are dealing with a female.

The skull (see figs. 1 to 6) is by far the most complete of this series, and also the most interesting. The main parts missing are the base, the internal facial bones, most of the right malar, the frontal process of the right maxilla, and much of the hinder parts of the palate and alveolar margins. There is some *post*

mortem deformation that has twisted the facial and frontal region slightly to the left, and compressed laterally the lower parts of the side walls of the brain box.

The skull is small and very light, and the bones are very thin and fragile. The vault is high, smooth and rounded, and free from all but the faintest possible traces of muscular relief. The two frontal bones are separated by a metopic suture which remains open for its entire length, both externally and internally. There is a jog in the coronal suture at bregma where the forward upper corner of the right parietal overlaps the hinder upper corner of the left frontal by 6 mm. For metrical purposes I established bregma at the midpoint of this overlap. The peak of the occiput ossified separately, forming a large diamond-shaped wormian bone 55 mm high by 50 mm across.

The nose is absolutely large and relatively broad, with smoothly rounded sills and a very prominent spine. The central incisors were removed by tooth knocking, but the alveolar prognathism remains pronounced on either side of the resultant hollowed-out area of absorption. The palate is relatively large, shallow, and hyperbolic.

The mandible, unlike the skull proper, is sturdy, and has a central triangular chin eminence. The alveolar prognathism is slight but definite, and the central incisors were removed by tooth knocking. The gonial angles are turned very slightly inward. Tooth wear is medium in general, slight on the third molars. There are no abscesses or pyorrhea. Four tiny cavities were noted in the lower molars and 8 in the upper. The dental arch of the mandible is U-shaped.

This skull is certainly not of the Mechta-Afalou type, in spite of a decided resemblance in the orbit shape, the nose, and the jaws, nor does it fit well into any series of which I have been able to find extensive individual measurements. It is apparently of hybrid origin. In most of its measurements and indices it conforms to the smaller form of the classic Mediterranean type, while the minority of its characters, in which it differs from that type, suggest the presence of Negroid and Mechta-Afalou elements in its genetic background.

At the same time we cannot overlook the fact that the face (exclusive of the forehead), the jaws, the palate, and what remains of the base, are definitely Boskopoid in form though not in absolute size (Galloway, '37), a condition also noted, though to a far lesser degree, in the Saharan negroid skeleton of Asselar (Boule and Vallois, '32), whose dating remains very uncertain (Monod, '46), but who was also apparently a hybrid, and certainly the victim of a tooth knocking ceremony.

SUMMARY AND CONCLUSIONS

My recent reexamination of Cole's Mechta series shows that the Upper Capsian population of Mechta-el-Arbi was undoubtedly mixed, and included elements of probably several distinct physical types. Among these we can identify with some assurance the following: (a) the Mechta-Afalou type, probably itself a locally stabilized hybrid of origins as yet unknown, (b) a small form of the classic Mediterranean, and (c) a definitely negroid element, which plays a minor role but one so widespread that we may suppose it to be relatively old in the area. In addition we note in one skull the presence of a constellation of characters of the face, mandible and skull base which are curiously suggestive of Boskop morphology in miniature. Boskop characters have been noted to a lesser degree in the undated and isolated Saharan skeleton of Asselar, which I personally am inclined to consider an out-and-out Negro rather than merely "negroid," although possibly also a hybrid.

In Cole's series we seem to have new evidence to support the theory that the late pre-Neolithic population of eastern Africa Minor included, in addition to the Mechta-Afalou type, "White" immigrants from the east (probably of several types) and an equally early wave of Negro (or negroid) immigrants, modified perhaps by Boskop contact, coming perhaps from the south or southeast.

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PLATE 1

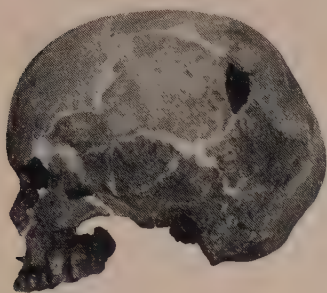
EXPLANATION OF FIGURES

All photographs of no. 3 are taken by Delorme, Algiers, courtesy of the Bardo Museum Laboratory. All photographs are approximately $\frac{1}{4}$ natural size, and were taken relative to the Frankfurt plane except figure 3, which was taken from slightly higher, and to the right of the sagittal plane.

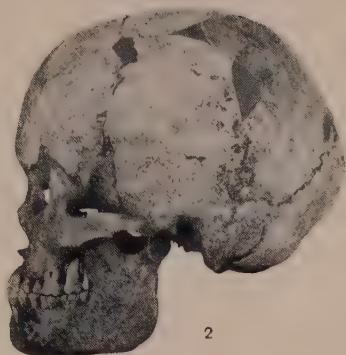
The "first" restoration was done in America; the "new" restoration is my own. Before photographing the "first" reconstruction (figs. 1 and 3), I removed the paint which, in Cole's plates, masks the plaster and putty. Thus, in figures 1 and 3 the restored parts are clearly distinguished, except for the reconstruction of the frontal process of the right maxilla which extended further downward than appears.

The numbers visible on the specimen were put on in America, and are not those of the catalogue of the Bardo Museum Laboratory; in the latter, Cole's nos. 1, 2 and 3 are numbered 39, 40 and 38 respectively (that is, in the order in which they were dealt with).

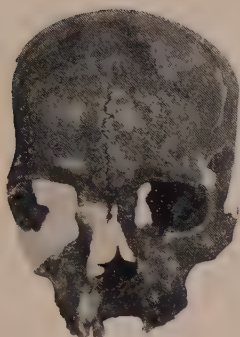
- 1 First reconstruction, norma lateralis
- 2 New reconstruction, norma lateralis
- 3 First reconstruction, facial view
- 4 New reconstruction, norma facialis
- 5 New reconstruction, norma occipitalis
- 6 New reconstruction, norma verticalis



1



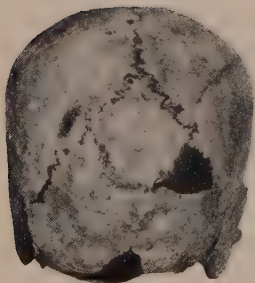
2



3



4



5



6



ORIGIN AND EVOLUTION OF MAN was the topic of the 15th Cold Spring Harbor Symposium on Quantitative Biology, held June 9-17 at the Biological Laboratory, Cold Spring Harbor, Long Island, New York. As Curt Stern reports:

"The conference was witness to the convergence of anthropology and genetics. The meetings were not so much a mutual education as a mutual consideration of problems of common concern. The speed in the spread of knowledge from one field to the others, and the bearing of contemporary studies in basic general genetics on problems in the special field of anthropological genetics, as well as the stimulus from the latter field to thinking in the former, made the symposium a most satisfactory experience" (Science, n. s. vol. 112, no. 2903, p. 209).

MUDR. JIŘÍ MALÝ of the faculty of Charles University in Prague died suddenly in his office on July 7, 1950 at the age of 51 years. Dr. Malý was one of the active members of the Anthropological Institute at Charles University. In 1929 he came to America and accompanied the late Dr. Aleš Hrdlička on a field trip to the Yukon River.

ERRATUM.—An error was made in stating the price of "The Anatomy of *Semnopithecus entellus*" by Ananthanarayana A. Ayer which was reviewed by William L. Straus, Jr., in this Journal, vol. 8, no. 1, pp. 127-129. The price is 20 rupees, instead of the 201 stated.

A STUDY OF THE STRUCTURE OF FRESH AND FOSSIL HUMAN BONE BY MEANS OF THE ELECTRON MICROSCOPE¹

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SIX FIGURES

The field of histology has progressed rapidly from the invention of the optical microscope through the development of the dark field, ultraviolet, and x-ray microscopes. The histologist has been able to see progressively greater detail as new microscopes were invented, but still there have been minute structures which were beyond their range. The development of the electron microscope has greatly extended this range, so that resolutions near the dimensions of a single molecule are now possible. We have taken advantage of the high resolution and magnification of this instrument in order to examine the minute structure of compact bone, with particular reference to the changes occurring during the so-called mineralization of bone.

Bone is one of the hardest tissues in the animal body. Its rigidity or hardness is attributed to the impregnation of the matrix with certain inorganic salts, particularly calcium phosphate and calcium carbonate. The organic part of the bone matrix contains osteomucoid and osteoalbuminoid which are commonly classed together as ostein.

¹ Acknowledgment with thanks is hereby made to the Viking Fund, Inc. of New York for financial assistance in defraying the charges incurred in connection with the use of the electron microscope. These funds were derived from a grant made to S. F. Cook, Division of Physiology, and R. F. Heizer, Department of Anthropology, for investigations on archaeological bone samples. Acknowledgment is also given to D. H. Copp, Division of Physiology, whose counsel has been invaluable.

The detailed histology is well described by Dawson ('48) and hence need not be recapitulated here. However, for purposes of orientation it may be mentioned that compact bone is made up of numerous layers of bony lamellae: the external circumferential, the concentric, interstitial, and the internal circumferential. The concentric lamellae surround the Haversian canals and, therefore, serve to form what are called

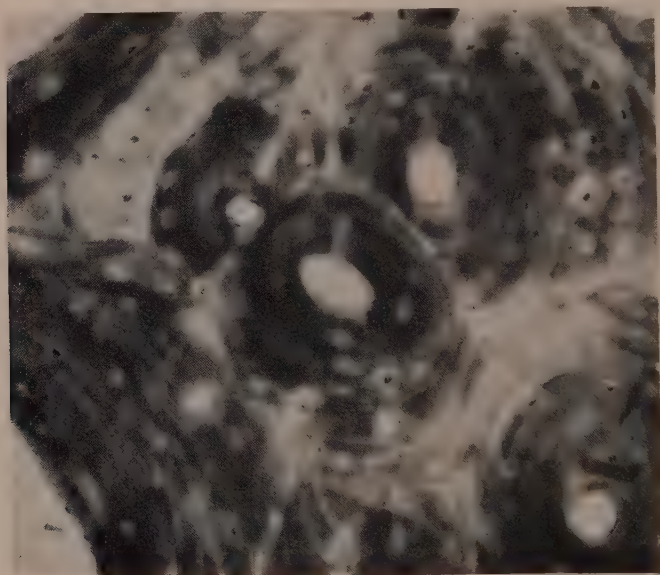


Fig. 1 Cross section of bone from human rib as seen with the light microscope. $\times 53$ natural size.

the Haversian systems (see fig. 1). These systems in turn are composed of (1) flat egg-shaped lacunae which in life contain the osteocytes or bone cells, (2) the canaliculae which radiate out from the lacunae and which in life contain the protoplasmic processes of the osteocytes, and (3) the main Haversian canals which hold the blood vessels that permeate bone.

Schafer ('29) has described the average diameter of a Haversian canal as about 50μ , more or less. Stirling (1893)

notes that the largest lacunae are about 14μ in diameter. These dimensions are well above the limiting resolving power of a good light microscope (0.2μ). It should be of interest to study the structures which may exist below this range, and recent advances in electron microscopy have made such studies possible.

Until the present time only a little work has been done on the minute structure of the rigid supporting tissues such as bone, cartilage, or teeth. The difficulties in sectioning these hard materials are obvious. Some good evidence of surface structure has been obtained by use of various replica techniques (Richards, '44; Gerould, '44; Gerould, '45).

PREPARATION OF THE SPECIMEN

Four types of bone were photographed with the electron microscope including fresh human bone and three mineralized or archaeological human specimens. The fresh human bone was obtained from the tibia of a 63-year-old normal white male. The ancient bones were derived from the aboriginal human inhabitants of central California whose remains were interred in the soil and until recently have remained undisturbed. All of the latter specimens were taken from the shaft of the femur, and although the exact physiological age of the individuals concerned is unknown, they were all well matured adults. As with most such material, it is difficult to give the precise archaeological age or even limit that age within a large range. The first bone was derived from a relatively recent site (C 138) and may have been from 200 to 500 years old. The second was from site C 107 and its age may be estimated in the range 4,000–6,000 years. The third was secured during the recent excavation of a site in Topanga Canyon, near Santa Monica. The site is as yet undated, but on cultural grounds appears nearly as ancient as C 107.

Pieces of compact bone were obtained which range from one to three inches in length. The size is of no particular consequence, the only requirement being that the piece be

large enough for the technician to grasp while it is being sectioned. The bone is cleaned by scraping the surface until a dirt-free lower layer has been reached. A heavy sharp scalpel is used to wedge-chip the specimen in its cross-sectional plane. The chips are then gathered in dust-free glass containers and are examined under the high power of a light microscope using a $6\times$ eyepiece. It will be noted that in order for the electron beam to penetrate the specimen, and show structural detail, the chip must be $1\ \mu$ or less in thickness (O'Brien, '43; Williams and Wyckoff, '44). The thinner the specimen the more detail is seen. We therefore made comparisons between the chips and materials of known thickness (fresh and dry erythrocytes). Many of the chips were found to be in the acceptable range.

A wire mesh screen is used as the specimen support instead of a glass slide. The screen is approximately one-half inch in diameter and has about 400 meshes per square inch. Electron rays will not pass through the wire of the screen, but will pass through the spaces between the meshed wires. It is the part of the specimen contained in these open spaces which we see.

The screens are prepared by the following method. Five drops of a 2.5% solution of Parlodion in amyl acetate are placed on the surface of distilled water which is contained in a pyrex bowl 10 inches in diameter. A thin film (about $0.01\ \mu$ or $100\ \text{\AA}$) is formed on the surface of the water and the screens are dropped upon this film. A glass slide is then held parallel to the surface of the screens and the film. It is pushed down, turned over, and withdrawn, bringing the film covered screens with it. These are then dried in a dust-free box. When dry the screens are knocked free and the sections are mounted on the film covered side of the screen.

For this purpose sections are examined under the high power of a light microscope and suitable ones are selected. These specimens are preferably $1\ \mu$ or less in thickness and are of the same order of magnitude as red blood cells. A

moist needle is directed to the particular chip and with the aid of capillary action it is picked up. The needle with its specimen is immediately moved to a screen which has been moistened by a drop of distilled water. Here with the aid of surface tension the chip is deposited. A number of sections are similarly transferred to the same and other screens. All are placed in dust-free containers, dried, and transported to the electron microscope.

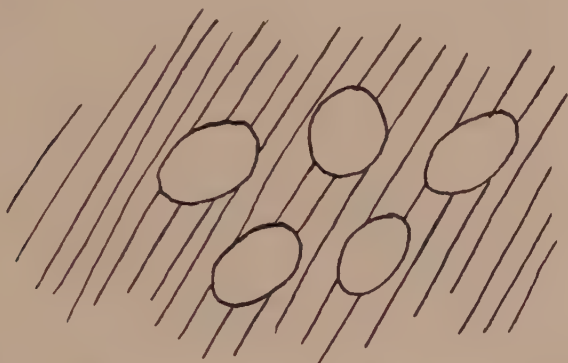


Fig. 2 Light and dark regions showing primary bone pattern.

METHODS OF MEASUREMENT

Representative positive prints of the electron micrographs will be found in figures 4, 5 and 6. These prints represent enlargements of about 64,000 times the actual specimen size, and may be compared with the photograph made with the ordinary light microscope shown in figure 1. It will be noted that these prints were made directly from the original electron micrograph negatives which were themselves about 8,000 times the actual specimen size. They were enlarged 8 times and printed on high contrast paper. Under these conditions it is difficult to bring out the fine detail and clarity that exists on the negative itself. It is possible, however, to obtain some idea of the actual pattern which represents the basic structure of compact bone.

A fundamental pattern appears in all of the bone specimens studied as seen on the negative. This pattern seems

to consist of light cavities which are surrounded and separated from each other by dark walls which are transparent to electrons (fig. 2). A secondary pattern appears in the C 107 specimens together with the primary pattern. This new type of pattern appears to consist of aggregates of small light spaces or cavities, surrounded by an amount of dark electron transparent material comparable to that seen in the primary pattern (fig. 3). The members of each group are separated from each other by thin walls of electron transparent material.²

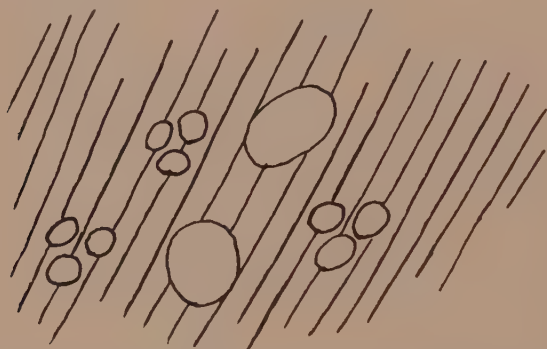


Fig. 3 Large light spaces of the primary type together with small light spaces of the secondary type.

Measurements were made from the negative using a micrometer disc in the $6\times$ eyepiece of a common light microscope. This procedure is considered more accurate than measuring the positive print itself. Still, it must be realized that a comparatively large error is possible. There are two principal reasons for this error. First, we note that the results obtained are a consequence of subjective observation and measurement. That is to say, the observer's consistency in method is relied upon for accuracy in measurement. This has been considered throughout and a large number of meas-

² It must be remembered that a dark area on the photographic negative is one which has been altered by electrons. The latter must, therefore, pass through the bone in order to reach the negative.

urements have been taken maintaining a constant method. A second possible source of error lies in the choice of points for measurement. Here the observer has exercised great care in selecting random areas for measurement. We know that when any histological section is made we can see areas which appear to be alike but which have different dimensions within the section. This stems from the fact that we have probably cut at various angles. Therefore, our level or method of cut is important. It is essential that the observer be as impartial as possible in the choice of areas to be measured and that a large number of observations be made in order to minimize these errors.

Three critical types of measurement have been taken. (1) The "middle to middle" measurement represents the distance from the middle of one light area to the middle of another. (2) "Light area" measurements represent the diameter or width of such a particular area. (3) Between the light areas exist "dark areas," separating the former from each other, which can be regarded as part of the pattern itself and which probably are composed of some type of more penetrable material. The width of these have been measured.³

To establish the fact that dust particles could not be responsible for the pattern seen, a check series of prepared mesh screens were exposed to dust from containers or from the laboratory. Although these dust control screens were made on every occasion, not once did they show any pattern remotely resembling that of the specimens.

The possibility of contamination from distilled water was also considered. In this case a series of water control screens were treated in the same manner as the specimen screens, with the exception that no specimen was placed on the screen. Here no contamination was noted in the wide majority of

³In addition there occur at random extensive areas of transparency on the negative, which are merely regions which are the result of imperfect sectioning and are too thick to allow any electron penetration. These are technical artifacts and have been disregarded as irrelevant to the structural pattern.

trials although in 1 out of 5 control screens there were a few very large opaque particles. These later pieces had no structure or pattern and did not resemble the bone specimens in any way.

The most effective evidence for the validity of the method stems from the fact that not once in the whole series of controls were particles found which in any way resembled the pieces termed bone sections, yet the same type of pattern was consistently obtained from the specimen-containing screens.

RESULTS AND DISCUSSION

Our electron micrographs of bone, as previously stated, show a consistent honeycomb-like pattern. This is made up of areas appearing light on the negatives and bounded by walls which appear dark. The light spaces are round or cuboidal in shape and range in diameter from 60 to 225 Å, which is far below the range of structures visible in histological sections under the light microscope. The canaliculae are the smallest structures seen in compact bone under the ordinary microscope and are about 0.3μ or 3,000 Å in diameter.

The pattern thus described appears consistently throughout the 4 human specimens studied and also in the femur of a rat which was examined for purposes of comparison. No other design is present, with one exception. This occurs in one bone, that derived from site C 107. In this specimen, which is very old, are seen smaller light spaces, arranged in groups of three (see fig. 3), which appear in conjunction with the primary pattern.

There are two possible explanations of the origin of the secondary pattern. (1) It represents a direct subdivision of a primary light space, through invasion by material deposited during burial in the soil. (2) It is inherent in the particular bone observed and substitutes locally for the primary pattern. Evidence bearing on the matter is derived from a set of 925 measurements made on 4 negatives from this bone with particular reference to this problem. Each measurement was

taken from the center of a light space to the center of an adjacent space. The distribution was featured by two sharply defined maxima, one at 115 Å, the other at approximately 190 Å. There is no evenly intergraded series, as one would expect if there were a gradual infiltration of materials to build up internal walls in a primary light space. Even more cogent is the fact that the mean *diameter* of the primary

TABLE 1

Mean measurements with electronmicrograph negatives. Series A is distance between centers of adjacent light areas. Series B is width of dark areas. Series C is width of light areas

	FRESH HUMAN BONE	BONE FROM SITE C 138	BONE FROM SITE C 107	BONE FROM TOPANGA SITE
<i>A</i>				
Number of measurements	50	50	50	32
Mean in Angstrom units	188	197	189	199
Standard error	± 2.52	± 3.00	± 2.75	± 4.70
Mean as per cent of <i>A</i>	100	100	100	100
<i>B</i>				
Number of measurements	50	50	50	32
Mean in Angstrom units	73.6	88.5	112.0	65.0
Standard error	± 1.70	± 1.97	± 2.35	± 1.64
Mean as per cent of <i>A</i>	39.1	44.8	59.2	32.6
<i>C</i>				
Number of measurements	50	50	50	32
Mean in Angstrom units	119.9	106.0	77.6	134.0
Standard error	± 1.90	± 2.37	± 2.60	± 4.18
Mean as per cent of <i>A</i>	63.8	53.8	40.1	67.3

light spaces (see table 1) is 77 Å, i.e., *smaller* than the mean distance between the secondary light spaces. It is necessary therefore to conclude that a variant of the primary pattern is possible. As to the frequency of its occurrence only the examination of many more bone samples can be decisive.

In table 1 are given the mean values for measurements made from the center of one primary light space to the center of the next. Such a mean is an index to the distribution of light and dark regions, and hence to the basic character

of the pattern itself. Now the values as set forth in the table are very close to each other numerically, the most divergent being separated by only 11 Å. Indeed if the critical ratio (or t value) of these two means is calculated it is found to be only 1.88, scarcely if at all significant. It is therefore permissible to conclude at once that in so far as these 4 bones are concerned not only does a fundamental bone pattern persist throughout but also within statistical limits it shows nearly identical geometrical distribution of material.

It is when we begin to examine the quantitative relationships between the two visible components — light and dark regions — that divergencies begin to appear. These relationships are best expressed in terms of the linear dimension: width or diameter of the light areas and width, or thickness of the dark areas. In table 1 the data are presented as the appropriate mean, with standard error of the mean. In addition, the relative value is indicated by expressing the mean for the light and dark spaces as a percentage of the mean distance between centers of light spaces. This is legitimate since the latter distance on the average would be equal to the sum of the widths of one dark and one light region.

According to the table as we progress from our fresh human sample to the bone from a recent site (C 138) to a very ancient site (C 107) the width of the dark spaces increases from 73.6 Å to 112 Å whereas simultaneously that of the light spaces diminishes from 119.9 Å to 77.6 Å. These differences are statistically significant. The relative amounts of the two components therefore alter radically. Since the basic or inherent pattern of the bone is substantially the same in all three cases we must conclude that the shift in relative quantity has been incurred during the sojourn of the prehistoric bones in the soil or, in other words, is due to fossilization. Most intriguing in this connection, however, is the condition of the Topanga bone, a specimen from what is known to be a very ancient site. This bone shows exactly the reverse trend since the dark areas are even narrower

than our normal bone (65 Å) and the light areas even larger (134 Å). It must consequently be immediately conceded that fossilization, if we wish to use the term, may cause submicroscopic bone alteration in more than one direction and therefore must involve several widely different types of processes.

Some light is shed upon the problem by considering the chemical nature of the bones concerned. In connection with another investigation complete analyses were performed, the results of which, in terms of percentage composition, are given in table 2.

TABLE 2

Chemical analyses of bones shown in table 1. All values are in per cent of whole bone by weight

SUBSTANCE	FRESH HUMAN BONE	BONE FROM SITE C 138	BONE FROM SITE C 107	BONE FROM TOPANGA SITE
Organic matter	34.7	10.5	2.7	1.71
Nitrogen	3.9	1.4	0.04	0.24
Water	7.00	5.74	2.66	2.75
Calcium	27.3	30.9	37.9	39.1
Phosphorus	8.6	14.0	11.7	14.3
Carbon dioxide	2.5	4.3	10.8	3.0

The chemical constituents are divided ordinarily into two groups, organic and inorganic. The first consists mainly of protein and is represented in the table by organic matter and nitrogen. The second includes calcium, phosphate, carbonate (as carbon dioxide) and probably water. Now it is most logical to conceive of the areas which are dark on the electronmicrograph negatives as being inorganic in nature. The light areas would then represent organic material. One reason for this point of view is the fact that the dark areas are continuous in the bone, whereas the light areas are dispersed. It is extremely difficult to imagine a solid mass of material such as bone in which the framework would be composed of semi-liquid material and the included masses would consist of mineral. A second reason is derived from con-

sideration of volumes. If, to take as an example our normal human specimen, we consider the light areas as being circular in cross section, having a mean radius of 60 Å and being 190 Å apart, then 23.5% of the area exposed is light. Furthermore, if the vertical distance between the light masses is also 190 Å and these masses are assumed to be spherical or nearly so, then roughly one-quarter of the total bone volume is composed of this material. This figure is quite close to that found by us for organic matter (34.7%) in this specimen, and is of the same order of magnitude as that generally ascribed to organic matter by other investigators.

If the above reasoning is correct, then the bone from site C 138 should show a relative decrease in organic material and increase in the inorganic components. The sample from C 107 should indicate an even more pronounced change of the same type. The data in table 2 bear out this prediction. One would conclude from these three cases alone that fossilization consists of a progressive loss of organic material with simultaneous accumulation of calcium salts, particularly carbonates.

The Topanga bone constitutes a flat exception. In the electronmicrographs the light spaces, indicating organic matter, have increased in size beyond even the normal bone, and the dark areas have diminished. Yet the chemical analyses (not only with this sample but also with many other similar specimens) show a very great reduction in organic matter. At the same time the calcium and phosphorus are very high, although the carbonate is surprisingly low. The correspondence between electronmicrographic changes and chemical changes noticed with the central California bones (C 138, C 107) breaks down completely.

At the present juncture there is no comprehensive hypothesis which will account for all the observed facts. It appears probable that fossilization, or mineralization, is no single simple process, but a complex of changes which may vary in direction and magnitude in accordance with factors the nature of which is not yet fully clear to us.

SUMMARY

1. Electron micrographs were made of very thin chips of compact bone. The specimens studied were fresh human, fresh rat bone, and archaeological specimens of human bone which had been interred in the ground.

2. All 4 specimens show a similar and consistent basic pattern which resembles a honeycomb with light spaces surrounded by dark electron transparent walls. These light spaces seem to be cuboidal in shape.

3. The dimensions of these structures range from 62 Å to 225 Å, which is smaller than the dimensions of even the smallest component in the Haversian system (canaliculae are 3,000 Å in diameter). This basic structural pattern of compact bone is far below the range of the light microscope. A secondary pattern consisting of smaller light areas appears in the C 107 specimen and probably represents a variation of the primary pattern.

4. The dark areas probably represent the inorganic components of compact bone, and the light areas organic.

5. Chemical analysis of the human bone specimens shows that in some cases there is a correspondence between chemical and physical alterations in bone during fossilization. One notable exception, however, indicates that more than one method or type of fossilization is possible.

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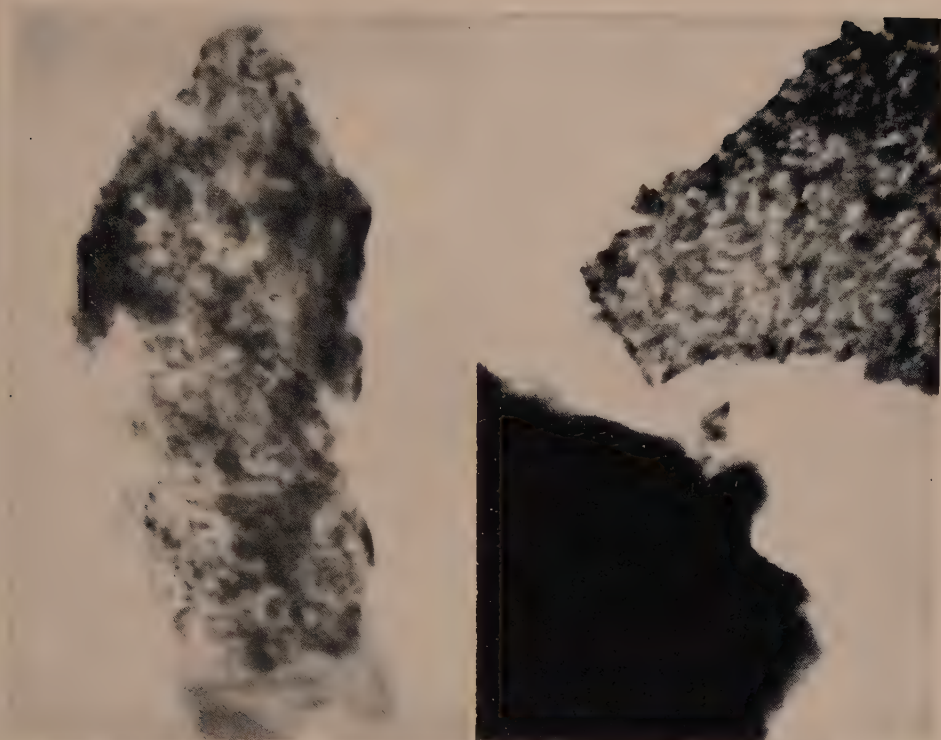
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PLATE 1

EXPLANATION OF FIGURES

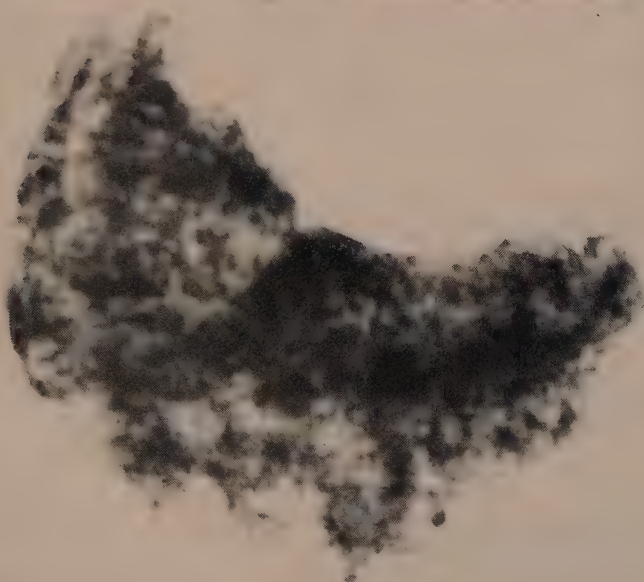
Representative positive prints of electron micrographs which were obtained from chips of compact bone. Approximately $\times 64,000$.

- 4 Fresh human bone.
- 5 Specimen from C 138.
- 6 Specimen from C 142.



4

5



6



RECENT FRENCH PUBLICATIONS.—L'Anthropologie contains the following articles of interest to physical anthropology:

Tome 54, nos. 1-2, for 1950:

- J. Avias: Les groupes sanguins des Néo-Calédoniens
(A, B, O, M, N, Rh) et des Océaniens en général du
point de vue de l'Anthropologie raciale p. 434-477

Tome 54, nos. 1-2, for 1950:

- J. Leschi: Empreintes digitales et races. Essai
de synthèse p. 35- 66
- Eugène Schreider: Les variations raciales et sexuelles du
tronc humain p. 67- 81

RECENT ITALIAN PUBLICATION.—The Rivista di Antropologia, vol. 36, 1948, contains the following articles of interest to physical anthropology:

- Sergio Sergei: Il secondo paleantropo di Sacco-
pastore p. 3- 95
- Antonio Ascenzi: Sulle proprietà ottiche dell'osso umano
normale et patologico. (Significato delle alterazioni ossee
nel morbo di Cooley) p. 97-119
- Venerando Correnti: Sulla correlazione tra peso e statura
nell'accrescimento. (Valutazione delle variazioni me-
diante il rilievo auxografico) p. 120-151
- Giorgio Canuto: La diametria del pelo come elemento
della sua identificazione individuale p. 152-158
- Alfredo Sacchetti: Sull'architettura del femore
umano p. 189-264
- Venerando Correnti: Sulla tecnica e sui metodi di
misurazione degli artri p. 304-314

SCAPULA SHAPE AND MUSCLE FUNCTION, WITH SPECIAL REFERENCE TO THE VERTEBRAL BORDER

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ONE FIGURE

Variations in the form of the scapula have long been of interest to anthropologists and have been the subject of a considerable body of literature from the last century to the present. These variations have been considered in the light of evolutionary, racial and constitutional studies: for example, Mivart (1868), Schultz ('30) and Miller ('32) describe differences in scapular form in the primates; Flower and Garson (1879), Hrdlička ('42a, b, c) and Gray ('42) discuss racial differences; Graves ('10, '21, '39) maintains the position that the form of the vertebral border is determined by intrinsic genetic factors, and that the scaphoid type (i.e., straight or concave vertebral border) is genetically associated with a pathologically weak constitution. Phylogenetically, the principal changes in the mammalian scapula have to do with the relative proportions of the supraspinous and infraspinous fossae, and the relative length of the scapula and of the acromion process. The length-breadth index may vary between racial groups, though evidence is still inconclusive on this point. This paper is chiefly concerned with the shape of the vertebral border, which has been investigated from the constitutional point of view.

Most of the studies up to now have been descriptive in nature, with very little attempt at explanation of the variations. As far as the vertebral border is concerned, the theories

advanced fall into two groups: on the one hand, Graves assumes genetic determination intrinsic to the bone itself, and on the other, Frey ('24), Hrdlička ('42a, b) and Kuhns ('45) believe that muscle function plays a large part in shaping this border. The following muscles have been suggested as important in this respect: rhomboid (Frey, Hrdlička and Kuhns), trapezius and serratus anterior (Kuhns), infraspinatus and subscapularis (Hrdlička, '42b). Kuhns also observed a correlation between persistent concave borders and total muscular relaxation, which suggests that general hypofunction of the shoulder muscles may affect the form of the scapula.

The evidence brought to bear on this problem up to now consists of observations on skeletal material, both adult and juvenile, and of clinical observations on growing children. But however important these descriptive studies are, the relative roles of intrinsic and extrinsic factors in shaping the vertebral border cannot be adequately elucidated without experimental work, in which the conditions of the living structural and functional complex can be more fully controlled (Washburn and Detwiler, '43). With this in mind, a project was undertaken which is described below. This experiment was done under the direction of Dr. S. L. Washburn, of the Department of Anthropology, University of Chicago, whose guidance and active participation in it are most gratefully acknowledged. Thanks are also due to N. A. Barnicot, Department of Anthropology, University College, London, for helpful criticism and suggestions. This investigation was aided by a grant from the Viking Fund.

MATERIALS AND METHODS

The object of this experiment is to determine whether or not the form of the scapula can be influenced during post-natal growth by the removal, at birth, of one or more muscles attaching to it. For this purpose rats were used, chiefly because of their short period of maturation. It is worth not-

ing, however, that the rodent shoulder girdle does approximate that of the higher primates (Inman et al., '44).

Unilateral operations using cold anaesthesia were performed on the first or second day after birth, and muscles were either severed at the line of attachment (trapezius, serratus anterior, rhomboid) or removed completely (supraspinatus, infraspinatus, subscapularis). The non-operated side served as a control, and on comparing this with the scapulae of normal animals no overcompensation effects were observed. The animals were all of the same strain, but in any case one type of operation was done on a single litter. The

TABLE 1

Type of operation and effect produced. (In all operations some reduction of the total size of the scapula was observed)

OPERATION (and number of cases)	EFFECT ON BONE
1. Muscles removed and/or severed	
a. rhomboid (9)	i. change in contour of supraspinous portion of vertebral border ii. decrease in size of supraspinous fossa
b. serratus anterior (6)	i. straightening of infraspinous portion of vertebral border ii. decrease in size of infraspinous fossa
c. trapezius, infraspinatus, supraspinatus (7)	i. spine greatly reduced or absent ii. supraspinous and infraspinous fossae reduced in size
d. supraspinatus (4)	i. medial portion of spine reduced ii. supraspinous fossa greatly decreased in size
e. trapezius, infraspinatus, supraspinatus, subscapularis (1)	i. supraspinous fossa absent ii. spine absent iii. infraspinous and subscapular fossae greatly reduced in size
2. Brachial plexus severed (6)	i. straightening of vertebral border ii. reduction in size of medial portion of spine iii. supraspinous fossa decreased in size

animals were killed between 77 and 82 days later, the condition of the muscles noted, and the scapulae then removed and cleaned.

In all, 33 operations were performed. The types of these, and the results obtained are listed in table 1, and representative cases are shown in the accompanying figure. On dissection it proved that removal of muscle was incomplete in some cases, so that variability in the results of any one type of operation may have been in part conditioned by this. The effects listed in the table represent the results of the most complete removals.

DISCUSSION

The results of this experiment may be divided into two groups: (1) those involving the vertebral border alone, and (2) those involving the scapular spine, and the size of the two fossae. Severing of rhomboid, serratus anterior and the brachial plexus is associated with the straightening of the vertebral border; removals of trapezius, infraspinatus and supraspinatus together, and of supraspinatus alone, and paralysis of the forelimb are associated with reduction of the spine and decrease in size of the supraspinous fossa; severing of serratus anterior and removal of trapezius, infraspinatus and supraspinatus together correlate with reduction of the size of the infraspinous fossa. In the one case where trapezius, infraspinatus and supraspinatus and subscapularis were removed, all the scapular fossae were reduced in size, the supraspinous being most affected; the spine was completely absent. It is important to note that such muscles as infraspinatus and subscapularis, which have a longer vertebral border attachment in man than in the rat, might be expected to affect the shape of the border more in man, whose scapula is longer (relative to breadth) and possessed of a relatively larger infraspinous fossa than that of the rat.

Severing of the brachial plexus was done chiefly to demonstrate that it is not a decrease of blood supply to the bone, which might occur due to crushing in muscle removals, which causes the changes in shape. However, the resulting changes

in the shape of the bone when the forelimb is paralyzed tend to confirm Kuhns' ('45) hypothesis concerning hypofunction (see below).

To deal briefly with the second group of effects: (a) the reduction of the scapular spine associated with removals of trapezius, supraspinatus and infraspinatus appears to belong to a category of conditions found elsewhere in the skeleton: observations on the crest of the tibia, and experiments on the nuchal crest (Washburn, '47) indicate that persistence of these formations in postnatal life depends upon the presence of functioning muscles (and enclosing fascia) in the immediate vicinity; (b) the effects observed on the size of the supraspinous and infraspinous fossae are possibly of considerable importance from a phylogenetic standpoint, since increase in the size of the infraspinous fossa relative to size of the supraspinous, and to total size of the bone, is one of the chief characteristics of anthropoid and human scapulae as distinct from those of quadrupedal mammals. Inman et al. ('44) have compared the relative masses of various shoulder-girdle muscles in a representative primate series, and point out a significant relationship between the relative size of the infraspinous fossa and the infraspinatus muscle. A more extensive analysis of comparative material would be a valuable companion study to a further group of operations designed specifically to demonstrate the influence of serratus anterior, rhomboid and trapezius, together with the muscles most directly related (supraspinatus, infraspinatus and subscapularis), on the relative size of the fossae.

Returning to the vertebral border, it is clear from this experiment that the belief of Kuhns, Frey and Hrdlička — that muscle function plays a large role in the shaping of this feature — is confirmed; it is now possible to maintain that function plays even a critical role. With respect to specific muscles, it appears that the suggestion of rhomboid, made by all three authors, and that of serratus anterior, made by Kuhns, are both confirmed. Kuhns' observation of a correlation between persistent concave borders and general muscular relaxation

is borne out by the effects of paralysis in the brachial plexus operation. Whether or not trapezius, infraspinatus and subscapularis, by themselves or in combination with others, have any influence, is still problematical and must be tested by further experiment.

Two additional considerations must be discussed here; the first concerns the evidence available on age changes in the scapula. Both Graves ('39) and Hrdlička ('42b) used skeletal material of different ages; Kuhns ('45) had a limited longitudinal series of children under observation for some years. Rather different results obtained between Graves and Hrdlička, Graves stating that scaphoid scapulae are more frequent in children than in adults, while Hrdlička's figures show a marked increase in the frequency of straight borders particularly between his "younger children" and "older children," with the higher frequency maintained in the adult group; this increase is almost entirely at the expense of the convex border type, which has a frequency of about 100% at birth. Concave borders appear in the "younger children" group with a frequency of about 5%, but their subsequent trend is not entirely clear; on the whole, however, concave borders are somewhat less common in adults than in children. In a different type of growth study, Kuhns observed concave borders changing into straight and convex in individual histories. The evidence afforded by skeletal material is obviously limited in value, inasmuch as both bodily activity and individual development can be only speculative, and the clinical evidence of Kuhns is thus a necessary counterbalance in these respects. Moreover, the longitudinal series provides a possible explanation for both Graves' and Hrdlička's figures concerning the age-incidence of the concave border. Neither Hrdlička nor Kuhns' found any correlation between concave borders and pathological conditions or susceptibility to disease, and in view of their results it seems highly unlikely that the scaphoid scapula is a mark of an inferior constitution doomed to an early death.

Finally, it is important to consider that the vertebral border is the last epiphysis of the human scapula to ossify and fuse (Schaeffer, '42); two ossification centers appear in it in the 15th year, and do not complete fusion until the 25th year. The same order is reported by Schultz ('44) for the gibbon and other catarrhines. There is considerable evidence (cited by Murray, '36) to show that while the initial form (in embryonic life) of endochondral bones is determined chiefly by intrinsic factors, the post-natal development and the final ossified form are very intimately related to functional conditions. Since the vertebral border is relatively slow in its bony development, there is presumably much scope for the play of extrinsic factors.

The experiment recorded here and the additional evidence, both actual and presumptive, of other investigators leave little doubt that the form of the vertebral border is very considerably influenced by the functional activity of at least some of the muscles attaching to it. In so far as the conclusions drawn by Graves are thus shown to be lacking in validity it is permissible to question the adequacy of his method, and along with it the very similar methods followed in many constitutional studies. It seems reasonable to conclude that only when we know the actual mechanics of growth in a given structure can we make valid statements about the relationship between its form and function.

SUMMARY

1. Variations in the shape of the scapula have been described in terms of phylogenetic, racial and constitutional differences.

2. These variations have been attributed by some to heredity and by some to function, particularly in the case of the contour of the vertebral border, which is an individually variable feature.

3. In the experiment described here, 33 operations were performed on newborn rats, in which muscles were removed or severed from the scapula; the results show that muscle

function greatly affects not only the shape of the vertebral border, but also the size of the scapular spine and the size of the fossae.

4. This kind of experiment is suggested as a necessary step in the understanding of the relationship between form and function in a given structure.

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PLATE

PLATE 1

EXPLANATION OF FIGURES

Upper pair. Left normal. Right scapula shows loss of spine (except for acromion region to which deltoid is attached) following removal of trapezius, infraspinatus, and supraspinatus.

Middle pair. Right normal. Left scapula shows great decrease in size of supraspinous fossa after removal of supraspinatus.

Lower pair. Right normal. Left shows great changes in size and shape after removal of the brachial plexus.





HOMINID DENTAL FEATURES OF THE AUSTRALOPITHECINAE.—According to my own comparative studies, based on more than four hundred ape skulls, the Australopithecine dentition displays certain hominid features which severally find no precise parallel in any of the known apes (recent or extinct), and others which may very occasionally be found singly if diligently sought in a large series . . . Among the features referred to are the small size (relative and absolute) and the spatulate form of the canine combined with its flat wear (by attrition with the opposing canine) and its relative position in the tooth row, the small incisors, the non-sectorial bicuspid form of Pm_3 (with cusps of approximately equal bulk and height and well-developed anterior and posterior foveae), the evenly curved parabolic contour of the dental arcade with a *consistent* absence of any diastema, the flat type of wear of the premolars and molars in the earlier stages of attrition, and, in the temporary dentition, the shape and dimensions (relative and absolute) of the milk canine combined with the details of the cusp pattern of dm_1 .

Many specimens of jaws and palates of the Australopithecinae, as well as numerous isolated teeth, have now been discovered and described, and at least three excellent specimens of the temporary dentition. All these bear witness to the fact that the same hominid pattern is quite consistently present in the Australopithecine dentition. So far as I am aware, no similar combination of *all* these hominid features together has been found in the dentition of any of the anthropoid apes.—W. E. LeGros Clark. South African Fossil Hominoids. *Nature*, vol. 165, no. 4205, June 3, 1950, pp. 893–894.

A COMPARISON OF CERTAIN ASPECTS OF BODY STRUCTURE AND BODY SHAPE IN 200 ADULTS

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SEVENTEEN FIGURES

INTRODUCTION

In the study of human constitution, the problem of classification is perennial. The morphological method has been suggested as the most satisfactory approach, and this is probably true, but morphological classification has its own problems. One of these is the measurement of the associations, if any, which exist between the external and internal aspects of the human body being classified; that is, of relating body form, "a surface phenomenon of constitution," to body build "a truly constitutional" phenomenon (Lessa, '43).

It is instructive, when surveying typologies which have been devised (Ciocco, '36; Tucker and Lessa, '40; Sheldon, Stevens and Tucker, '40; Krogman, '41; Lessa, '43), to separate those methods in which the internal structure of the body has been the principal point of reference, from those studies in which the external body shape has provided the classificatory tools.

Speaking very generally, the "internalists" have tended to be little concerned with external appearance, while the "externalists" have to a large degree assumed that their variables bear a meaningful relation to internal structure, or have ignored the problem.

Now the several factors which may be associated with human behavior most certainly include both the materials with which the body is made — the internal structure — and the external

shape and appearance of these materials. Body structure permits various activities, both physical and mental, within a certain range. External shape and appearance often elicit, within a specific culture, certain preferential responses. In the former case, problems lie chiefly in the realms of morphology and physiology; in the latter case, anthropological, psychological and sociological aspects of human behavior must also be considered.

It becomes of some importance, therefore, when employing a particular typology, to know as precisely as possible which aspects of the organism are being studied, and to what degree. Does a certain classification, derived from measurements and observations taken on photographs, bear any significant relationship to structure? How is it related, for instance, to the distribution of the various tissues within the body? Or again, to what degree does an individual, whose external shape tends to resemble the opposite sex, have an internal distribution of tissue components which similarly resembles the opposite sex? In general, to what degree are people who look alike made alike?

In some studies, a problem may be concerned solely with the relationship between external appearance and behavior, regardless of internal structure. This is a perfectly legitimate problem, but in such cases it would seem important to establish that there is no external-internal association, or, if such an association exists, to measure and make the proper allowance for its possible influence.

On the other hand, if there is any assumption that an externally derived typology is associated with basic biologic development or structure, and that in measuring the surface we are getting at the interior, then certainly an effort should be made to establish the degree of the presumed association.

In the present paper, we are describing certain aspects of body structure in the adult, and comparing our results with observations of body shape. We have obtained, from roentgenograms, measurements which give some idea of the distribution of three tissue components of the body. On these

same cases we have obtained, from body measurements and photographs, several measures of body size and descriptions of body shape. The paper will be concerned with the degree of association which exists between these factors in our series.

MATERIALS AND METHODS

The 100 men and 100 women in the present study are for the most part parents of the children enrolled in the long-term study of human growth being conducted by the Fels Research Institute (Sontag, '46). In this category are 83 men and 89

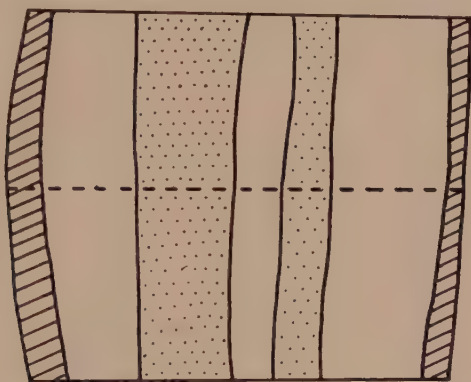


Fig. 1 Tracing of an anteroposterior roentgenogram of the left leg. Striped areas, subcutaneous fat (plus skin); stippled areas, tibia and fibula; open areas, muscle masses. The broken line represents the level at which the tissue breadths are measured.

women. The remaining cases were recruited from Fels staff and from a few adult volunteers.

Ages range from 19 years to 70 years, with a mean age of 37.8 years for the men and 38.0 years for the women. The relation of age to the factors being studied will be discussed in a later section.

On each adult, an anteroposterior roentgenogram of the left leg was taken, at the level of greatest breadth of calf. The focal-film distance was 6 feet, with the subject standing, feet pointing directly forward, weight evenly distributed, and calf

of leg touching cassette without pressure. On such a roentgenogram (fig. 1), it is possible to distinguish the shadows representing the total breadth of leg, the thickness of tibia and fibula, the extent of the muscle masses, and the breadth of the subcutaneous adipose tissue (plus skin). The following measurements were taken on each roentgenogram:

1. *Breadth of "fat."* The sum of the thickness of medial and lateral subcutaneous adipose tissue (plus skin).
2. *Breadth of bone.* The sum of the breadths of tibia and fibula.
3. *Breadth of muscle.* The sum of the thickness of the muscle masses lateral to the fibula, medial to the tibia, and the interosseous breadth.
4. *Total breadth of calf.* This equalled the sum of items 1, 2 and 3.
- 5, 6, 7. The *relative breadths* of items 1, 2 and 3. The breadth of the individual component times 100, divided by the total breadth of calf.
8. The *fat/bone index*. Item 1 times 100, divided by item 2.

Further details of technique, and discussions of advantages and limitations of this method, are contained in earlier studies (Reynolds, '44, '46, '48, '49; Reynolds and Asakawa, '48; Reynolds and Clark, '47; Reynolds and Grote, '48; Reynolds and Schoen, '47).

On each subject, a number of body measurements were taken, of which weight, height and calf circumference will be discussed. The calf circumference was taken at the same level on the leg as the roentgenometric measurements, and the coefficient of correlation (r) between the two items is $+.92$ for men and $+.94$ for women.

Photographs, in front, side and rear views, were taken on 86 men and 89 women. Fifty-five of the male and 65 of the female photographs are nudes, the others being chiefly shorts or bathing suits. Classifications of body shape, derived from inspection and ratings of photographs, will be discussed in a later section.

RESULTS

The factor of age. The relation of age to the tissue breadths, as well as to weight and height, was examined by the coefficient of correlation. The results are shown in table 1. The associations between age and tissue breadths are low in the present series. Two coefficients, an r of $-.24$ for age and muscle breadth in the men, and an r of $+.21$ for age and fat breadth in the women, reach the 2% level of significance.

TABLE 1
Correlation of age with tissue breadths, weight and height

ITEMS	MEN (N = 100)	COEFFICIENT
Age and breadth of fat		.008
Age and breadth of muscle		— .241
Age and breadth of bone		— .069
Age and total breadth of calf		— .201
Age and weight		— .000
Age and height		— .172
ITEMS	WOMEN (N = 100)	COEFFICIENT
Age and breadth of fat		.208
Age and breadth of muscle		— .006
Age and breadth of bone		.132
Age and total breadth of calf		.128
Age and weight		.215
Age and height		— .302

In the men, the relation of age with weight and height was not significant, but in the women, the r of $+.22$ between age and weight, and $-.30$ between age and height, were significant at the 2% level or better.

In general, age does not seem to be an important factor in the present series, no coefficient being larger than .30.

Intercorrelations of tissue breadths. These are shown in table 2. The associations between fat, muscle and bone breadths are low, the coefficients ranging between $-.03$ and

+ .22. One value, the r of .22 between fat and muscle breadths in the men, is significant at the 5% level. The correlations of the individual tissue breadths with total calf breadth are moderate in size, ranging between + .27 and + .88, all being significant at the 1% level.

Relations of tissue breadths to weight and height. The coefficients of correlation are shown in table 3. Weight is significantly associated with all three tissue breadths, and with

TABLE 2
Intercorrelation of tissue breadths

ITEMS	MEN (N = 100)	COEFFICIENT
Breadth of fat and breadth of muscle		.224
Breadth of fat and breadth of bone		— .033
Breadth of muscle and breadth of bone		.077
Breadth of fat and total breadth of calf		.550
Breadth of muscle and total breadth of calf		.880
Breadth of bone and total breadth of calf		.365

ITEMS	WOMEN (N = 100)	COEFFICIENT
Breadth of fat and breadth of muscle		.160
Breadth of fat and breadth of bone		.008
Breadth of muscle and breadth of bone		.053
Breadth of fat and total breadth of calf		.658
Breadth of muscle and total breadth of calf		.786
Breadth of bone and total breadth of calf		.266

total breadth of calf. Height is significantly related only to bone, in the women. The r between weight and height in the present series is + .35 for the men and + .30 for the women. Bone breadth tends to be less highly related to weight than the other two tissues, and more highly related to height.

When these associations are further examined, in terms of partial coefficients of correlation (table 4), all three tissue breadths show a positive association with weight, while fat and muscle show a negative association with height. Bone

breadth, with weight held constant, shows a low positive association with height.

Norms and distributions of tissue breadths. Norms for the 8 tissue variables, and sex differences as shown by critical ratios, are given in table 5. Differences between the sexes are significant throughout, the men having both absolutely and

TABLE 3
Correlation of tissue breadths with weight and height

ITEMS	MEN (N = 100)	COEFFICIENT
Breadth of fat with weight		.615
Breadth of muscle with weight		.480
Breadth of bone with weight		.314
Total breadth of calf with weight		.716
Breadth of fat with height		.106
Breadth of muscle with height		.000
Breadth of bone with height		.148
Total breadth of calf with height		.087
Weight with height		.348
ITEMS	WOMEN (N = 100)	COEFFICIENT
Breadth of fat with weight		.510
Breadth of muscle with weight		.580
Breadth of bone with weight		.378
Total breadth of calf with weight		.790
Breadth of fat with height		— .062
Breadth of muscle with height		.171
Breadth of bone with height		.358
Total breadth of calf with height		.170
Weight with height		.301

relatively thicker muscle masses and bones, and the women thicker subcutaneous fat. It will be noted that the sex differences are much more pronounced for the individual tissue components than they are for the total breadth of calf. The fat/bone index is significantly lower in the men (Reynolds, '49).

TABLE 4

Partial correlation of tissue breadths with weight and height

MEN (N = 100)		PARTIAL COEFFICIENT
ITEMS		
With height held constant:		
Breadth of fat and weight		.625
Breadth of muscle and weight		.512
Breadth of bone and weight		.278
With weight held constant:		
Breadth of fat and height		— .146
Breadth of muscle and height		— .204
Breadth of bone and height		.047

WOMEN (N = 100)		PARTIAL COEFFICIENT
ITEMS		
With height held constant:		
Breadth of fat and weight		.555
Breadth of muscle and weight		.563
Breadth of bone and weight		.306
With weight held constant:		
Breadth of fat and height		— .260
Breadth of muscle and height		— .005
Breadth of bone and height		.279

TABLE 5

Norms and sex differences for absolute and relative tissue breadths, total breadth of calf, and the fat/bone index (N = 100)

ITEM	MEN		WOMEN		CRITICAL RATIO
	Mean	S. D.	Mean	S. D.	
Absolute breadths (mm):					
Fat	10.8	3.59	20.5	5.95	14.0
Muscle	67.4	7.31	60.3	7.56	6.7
Bone	39.4	3.02	32.5	2.39	17.9
Total calf breadth	117.5	9.49	113.4	10.42	3.0
Relative breadths (%):					
Fat	9.3	2.96	17.9	4.25	16.6
Muscle	57.3	2.44	53.2	4.09	8.6
Bone	33.7	2.99	28.8	3.24	11.0
The fat/bone index (%)	27.6	9.61	62.2	19.90	15.6

Sex differences in tissue distribution, and individual deviations in tissue breadths, have been further examined by direct comparisons of frequency distributions for each variable. By inspection of the distribution tables for each item, a division was made at the point where the overlap between men and women was minimal. For example, in the fat/bone index, the

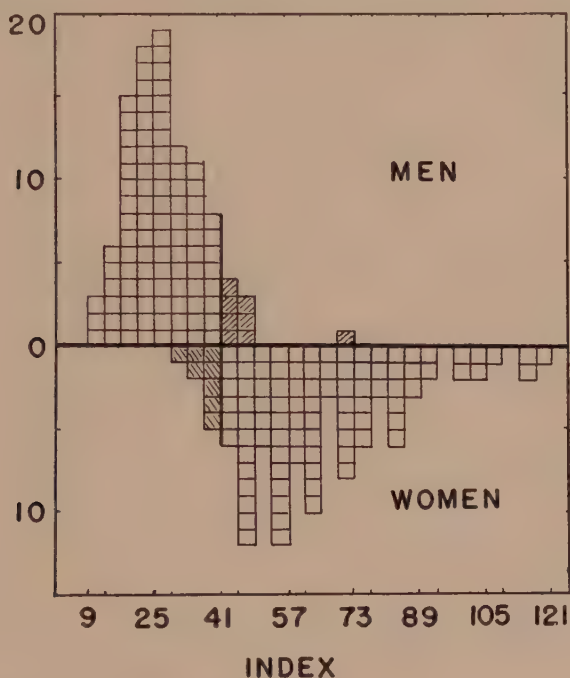


Fig. 2 The distribution of the fat/bone index in 100 men and 100 women. The shaded areas represent individuals within the range of the opposite sex.

point of division fell between 40 and 41. That is, individuals with an index of 40 or less are considered to be in the male range, and those with an index of 41 or more in the female range. This procedure placed 92 men and 8 women in the male range, and 92 women and 8 men in the female range. This is shown graphically in figure 2, and the results of similar comparisons for the various items are shown in table 6.

Individual deviations in tissue distribution. When the distribution of tissue breadths in individual cases is examined, the majority of cases lie entirely within the ranges of their own sex. About a third of the cases have one tissue breadth outside the range for their own sex, while 5 men and 7 women have patterns of tissue distribution in which two of the three tissue breadths lie within the range of the opposite sex. One man has all three of his absolute tissue measurements within the female range, but none of the women is so deviant. These findings are shown in table 7.

TABLE 6
Analysis of frequency distributions
($N = 200$)

ITEM	MALE RANGE	FEMALE RANGE	DISTRIBUTION OF MEN		DISTRIBUTION OF WOMEN	
			Within range	Outside range	Within range	Outside range
Absolute breadths (mm):						
Fat	14-down	15-up	85	15	85	15
Muscle	64-up	63-down	77	23	72	28
Bone	36-up	35-down	92	8	88	12
Total calf	(Cannot be separated; too much overlap in distributions)					
Relative breadths (%):						
Fat	12-down	13-up	89	11	88	12
Muscle	56-up	55-down	71	29	69	31
Bone	32-up	31-down	76	24	81	19
The fat/bone index (%)						
	40-down	41-up	92	8	92	8

When the photographs of those individuals showing marked deviations in tissue distribution are examined, and compared with the non-deviant group, an impression is gained that an unusual pattern of tissue distribution is associated with an unusual body shape. Plate 1 shows photographs of 4 of these deviants: a man with fat and bone breadths in the female range; a man with muscle and bone breadths in the female range; a woman with fat and muscle breadths in the male range; and a woman with muscle and bone breadths in the male range.

The impression that there is an association between deviations in tissue distribution and deviations in body shape is strengthened if attention is turned to the distribution of the fat/bone index. In table 8, means are given for 8 men who lie in the feminine range of the fat/bone distribution. These

TABLE 7

Analysis of individual cases, in terms of distribution of absolute tissue breadths within male or female range

(N = 100)

DISTRIBUTION OF PATTERN	MEN NO.	WOMEN NO.
All three tissue breadths within male range	61	0
Fat breadth in female range, other two tissue breadths in male range	11	3
Muscle breadth in female range, other two tissue breadths in male range	19	1
Bone breadth in female range, other two tissue breadths in male range	3	3
Fat and muscle breadths in female range, bone breadth in male range	1	8
Fat and bone breadths in female range, muscle breadth in male range	2	22
Muscle and bone breadths in female range, fat breadth in male range	2	11
All three tissue breadths within female range	1	52
	100	100
Recapitulation:		
Three breadths male, none female	61	0
Two breadths male, one female	33	7
One breadth male, two female	5	41
Three breadths female, none male	1	52
	100	100

“hypomascuine” men, with indices of 41 and higher, are compared with 9 “hypermascuine” men, with a fat/bone index of 16 and lower. In like manner, a comparison is made of 8 “hyperfeminine” women (index of 97 and higher), with 8 “hypofeminine” women (index of 40 and lower). There are, of course, marked differences in tissue distribution, as this

was a factor in the selection of cases for comparison. In the men, a high fat/bone index is associated with thicker legs, heavier weight, a lower ponderal index, with more fat and less bone, and, relative to the size of the leg, much more fat and less muscle and bone. These factors are all in the direction of less masculinity of structure. Inspection of the photographs suggests that, in the men, a higher fat/bone index is definitely

TABLE 8

Mean values for individuals with the highest fat/bone index in the series compared with individuals having the lowest fat/bone index in the series

ITEM	MEN		WOMEN	
	With high index	With low index	With high index	With low index
Number of cases	8	9	8	8
Fat/bone index (%)	47	13	107	36
Absolute breadths (mm):				
Fat	17	5	33	12
Muscle	71	66	63	61
Bone	36	39	31	33
Total calf breadth	124	110	127	106
Relative breadths (%):				
Fat	14	5	26	11
Muscle	57	60	50	58
Bone	29	35	24	31
Weight (kg)	79.3	66.6	75.4	53.8
Height (cm)	176.7	175.0	161.4	163.2
Ponderal index (%)	41.3	43.3	38.5	43.3
Calf circumference (cm)	37.9	34.3	38.6	32.8

associated with a less masculine body shape, and a lower fat/bone index with a more masculine body shape.

In the women, a high fat/bone index is associated with the same structural factors as it is in the men, that is, with a greater femininity of structure. Again, the photographs indicate that a high fat/bone index is associated with a more feminine body shape, and a low fat/bone index with a less feminine body shape.

Tissue distribution and androgyny score. The results described, based on simple inspection, seemed promising enough to follow up with more objective comparisons. Therefore, the cases whose means were presented in table 8 were further examined by means of the androgyny scales devised by Bayley and Bayer ('46). This expresses numerically the degree of masculinity-femininity of body shape an individual possesses, with typical masculine scores ranging from 13 through 17 units, and typical feminine scores ranging from 28 through 34 units. The method was devised for assessing androgyny scores on young adults, but appears to be equally applicable to more mature individuals.

TABLE 9

The relation of fat/bone index to androgyny score

GROUP (5 cases in each group)	FAT/BONE INDEX		ANDROGYNY SCORE	
	Range	Mean	Range	Mean
"Hypomasculine" men	42-46	44	18.0-23.0	20
"Hypermasculine" men	10-16	14	14.5-17.5	16
"Hyperfeminine" women	103-120	111	34.0-40.0	37
"Hypofeminine" women	35-39	38	27.0-30.3	29

There were 5 sets of nude photographs available for each of the 4 categories of tissue distribution being examined, and the results of applying the androgyny scales to these 20 cases are shown in table 9. A photograph of an individual from each of the 4 groups, together with fat/bone index and androgyny score, is shown in plate 2.

Each sex shows a marked agreement between androgyny score and fat/bone index. This is seen most clearly in the scattergram shown in figure 3. It will be noted that, in the men, the range of the fat/bone index is smaller, and that the "hypomasculine" males have a slightly higher fat/bone index and a lower androgyny score than the "hypofeminine" women.

Tissue distribution and somatotype. All available photographs were used in this analysis. For each sex, 5 cases were

selected, showing strong dominance of endomorphy, following Sheldon's classification. Similar selections were made for extremes of mesomorphy and of ectomorphy.

For the men, no effort was made to obtain a numerical somatotype, but each man chosen represented, in our opinion, a marked dominance in one of the components.¹ For the

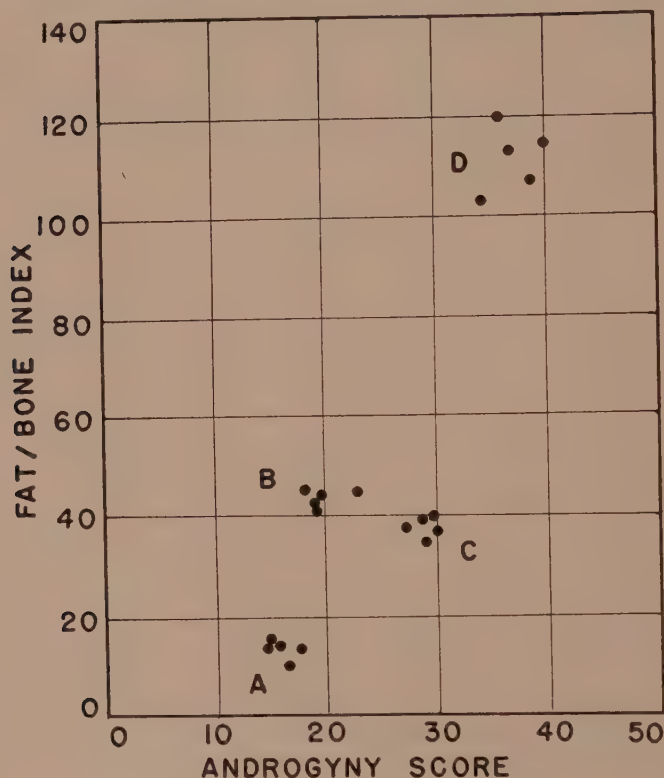


Fig. 3 Scattergram of fat/bone index versus androgyny score for 20 selected cases. (A) "hypermasculine" men; (B) "hypomaseuline" men; (C) "hypofeminine" women; (D) "hyperfeminine" women.

¹ Dr. Barbara Hirsch and Mrs. Tempest-Holmes, from the Constitution Clinic, Columbia College of Physicians and Surgeons, visited the Institute while this study was in progress, and gave valuable advice and assistance in the somatotyping of our photographs. However, the responsibility for the final selection of cases rests with the authors.

TABLE 10

Comparison of the means for individuals representing extremes of endomorphy, mesomorphy and ectomorphy

ITEM	MEN			
	Group	Endomorphs	Mesomorphs	Ectomorphs
Number of cases	100	5	5	5
Absolute breadths (mm):				
Fat	11	18	9	9
Muscle	67	70	73	60
Bone	39	37	40	37
Total breadth of calf	117	125	122	106
Relative breadths (%):				
Fat	9	14	7	8
Muscle	57	56	60	57
Bone	34	30	33	35
Fat/bone index (%)	28	48	24	24
Weight (kg)	74.1	84.1	77.2	61.0
Height (cm)	176.1	176.4	177.5	178.2
Ponderal index (%)	42.1	40.4	41.8	45.3
Calf circumference (cm)	36.1	37.7	36.8	33.2

ITEM	WOMEN			
	Group	Endomorphs	Mesomorphs	Ectomorphs
Number of cases	100	5	5	5
Absolute breadths (mm):				
Fat	20	31	17	14
Muscle	60	67	66	52
Bone	33	33	34	30
Total breadth of calf	113	131	117	96
Relative breadths (%):				
Fat	18	24	15	15
Muscle	53	51	56	54
Bone	29	25	29	31
Fat/bone index (%)	62	94	50	46
Weight (kg)	62.2	91.4	66.0	45.9
Height (cm)	162.6	162.2	165.9	160.9
Ponderal index (%)	41.3	36.0	41.1	44.9
Calf circumference (cm)	34.7	40.3	35.6	29.9

women, numerical somatotypes were obtained, using the method of Bullen and Hardy ('46). The endomorphs in the women were 621, 622, 711, 631, 621; the mesomorphs, 352, 352, 352, 253, 251; the ectomorphs, 126, 225, 135, 225, 235. Plate 3 shows a man from each group, and plate 4 a woman from each group.

Table 10 shows means of various items for each group of somatotypic extremes, as compared to the means for the entire series. The findings of this table may be summarized briefly as follows:

Endomorphs: Are the heaviest group in weight, with the lowest ponderal index and the thickest legs; have much more fat; have, relative to size of leg, the most fat and the least muscle and bone; have a high (feminine) fat/bone index.

Mesomorphs: Are the intermediate group in weight, ponderal index and size of calf; have the largest bones and large muscles; have, relative to size of leg, the most muscle; have a low fat/bone index.

Ectomorphs: Are the lightest group in weight, with the highest ponderal index and the thinnest legs; have the least fat, muscle and bone; have, relative to size of leg, the thickest bones; have a low fat/bone index.

These results indicate that there is an association, in the present series, between somatotype extremes and tissue distribution, as we have defined it. Endomorphs dominate in fat, mesomorphs in muscle, and ectomorphs in bone. Endomorphs have a feminine distribution of the fat/bone index, for both sexes, with the women of course having much the higher values. Both mesomorphs and ectomorphs have a fat/bone index lower (more masculine, less feminine) than the group mean for the respective sex.

Weight, ponderal index and calf circumference show a consistent relation to somatotype, in both sexes. Height does not; the male ectomorphs are slightly the tallest group, the female ectomorphs the shortest group. The mesomorphs are taller than average in both sexes, and the endomorphs very near the group mean for each sex.

It should be emphasized that these results deal only with differences between extremes, where the climate is, so to speak, most conducive to discovery. Examination of a larger series of cases, throughout the entire range, is a logical sequel to the present exploratory study, and we are presently engaged in such an undertaking.

SUMMARY

1. Measurements were taken of breadth of fat, muscle and bone, as seen in roentgenograms of the leg in 100 men and 100 women, ages 19 to 70 years.

2. Weight, height, calf circumference and photographs were also taken. Assessments of androgyny (Bayley and Bayer) were made on selected cases, and extremes of endomorphy, mesomorphy and ectomorphy (Sheldon) selected.

3. Intercorrelations between tissue breadths are low. Tissue breadths correlate significantly with weight, but not with height. Age is not an important factor in the present series, as measured by the correlation coefficient.

4. Men have significantly larger legs, more muscle and bone, and less fat than women. Sex differences in tissue distribution are much more pronounced than in size of leg.

5. The distribution of tissue breadths in each individual case was examined. Marked deviation in tissue distribution tends to be associated with a deviant body shape. Individuals with a tissue distribution characteristic of the opposite sex have a body shape tending to resemble the opposite sex.

6. There is a close association between the distribution of the fat/bone index and masculinity-femininity of body shape, as measured by androgyny scores.

7. When somatotype extremes are compared, endomorphs are heaviest in weight, with lowest ponderal index, thickest legs, most fat and relatively least muscle and bone. Mesomorphs are intermediate in size, with largest bones and relatively largest muscles. Ectomorphs are lightest in weight, with highest ponderal index and least fat, muscle and bone; they have relatively the thickest bones.

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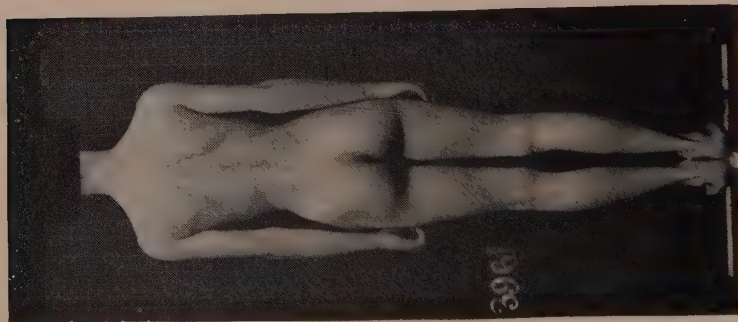
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PLATES

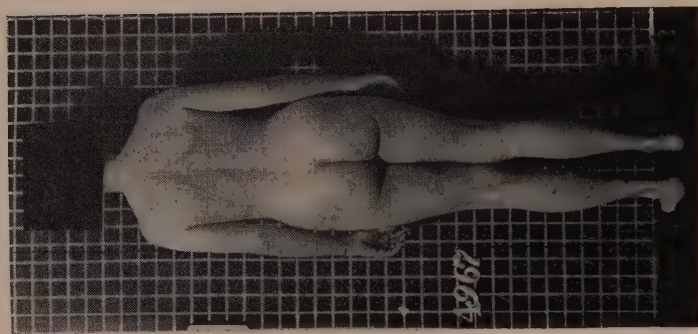
BODY STRUCTURE AND BODY SHAPE
EARLE L. REYNOLDS AND TOSHIKO ASAKAWA



4



5



6



7

Body shape of individuals showing deviations in tissue distribution.

4 A man with fat breadth and bone breadth in the female range.

5 A man with muscle breadth and bone breadth in the female range.

ANTHROPOMETRY OF EXTREME SOMATOTYPES

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ONE FIGURE

This report presents the results of an anthropometric study made on a series of 30 young adult male whites from New York City all of whom are examples of fairly extreme dominance in one or other of the three components recognized in Sheldon's ('40) somatotyping system. Among the 30 subjects are 10 endomorphs, 10 mesomorphs and 10 ectomorphs. They were originally selected by inspection from large groups of young men in colleges, gymnasiums and YMCA's on the basis that they appeared to be extreme in their respective dominant component. Upon subsequent examination of their somatotype photographs, however, it was found that most of them attained a rating of 7 in their dominant component but a few did not. The component averages for the three groups turned out to be $7 \cdot 2\frac{1}{2} \cdot 1$, $2\frac{1}{2} \cdot 6\frac{1}{2} \cdot 1\frac{1}{2}$ and $1\frac{1}{2} \cdot 2 \cdot 6\frac{1}{2}$ respectively. These 30 men represent about as good a sample of extreme somatotypes as one is likely to find in a population of approximately 1000 young adult males. The object of this anthropometric study was to discover just how different these groups of extreme physiques are in terms of conventional measurements and also to determine which measurements might prove useful in discriminating between different somatotypes.

Although the members of each group are not all of the same somatotype they are similar enough to warrant grouping them as examples of extreme or nearly extreme somatotypes. Nearly all possess most of the characteristics associated with maximum rating in one of the three components. The endomorphs exhibit pronounced round softness of the body with great

central concentration of mass and relatively weak, tapering extremities. The mesomorphs have extraordinarily well developed musculature throughout the body and massive skeletal structure. Excessive linearity and delicacy characterizes all of the ectomorphs. They stand out in sharp contrast to the more massive physiques.

The author is well aware that samples of 10 individuals although highly selected are not sufficiently large to warrant elaborate statistical analysis, nor are they of great value for predictive purposes. Nevertheless, since extreme somatotypes are a real rarity in any population it was felt that measurements made on these few subjects might prove of interest to those who are concerned with variations in the human physique.

ANTHROPOMETRIC TECHNIQUES EMPLOYED

Most of the measurements were made according to standard anthropometric technique. A few, however, need to be described since they were devised especially for this study. Upper arm circumference was taken midway between acromion and radiale; lower arm circumference was taken at the point of maximum girth; thigh circumference was taken midway between anterior iliac spine and tibiale; calf circumference was a maximum measurement of the lower leg. Femur length was measured from anterior iliac spine to tibiale and total leg length was calculated by subtracting sitting height from stature. Neck circumference was taken just above the thyroid cartilage. All extremity measurements were made on the left side of the body.

The means and standard deviations of the measurements for all three series are presented as well as the corresponding statistical constants for certain indices calculated from the measurements. In addition, the standard needle point measurements described by Sheldon were made on the films of the somatotype photographs. The means of these measurement-stature ratios are offered as supplementary evidence of the

great variations in morphological structure exhibited by these groups of extreme somatotypes.

A word must be said here concerning the reliability of anthropometric measurements made on living subjects. Most anthropologists agree that accuracy of measurement varies almost directly with difference in body build. Many of the measurements taken were originally designed to determine the dimensions of the skeleton. It is obvious that diameters taken on slender, lean subjects more nearly approach the true skeletal dimensions than those taken on obese or heavily

TABLE 1

Mean values for age, height and weight for New York and Sheldon series of extreme somatotypes

	ENDO	MESO	ECTO
<i>Age</i>			
New York Series	21.3 yrs.	22.3 yrs.	25.9 yrs.
Sheldon Series	18	18	18
<i>Height</i>			
New York Series	177.8 cm	175.2 cm	183.0 cm
Sheldon Series	174.3	174.0	181.7
<i>Weight</i>			
New York Series	257.7 lbs.	181.9 lbs.	131.5 lbs.
Sheldon Series	208	165	121.5

muscled people. Caution, therefore, must be exercised in interpreting some of the differences of means between the three series.

AGE, HEIGHT AND WEIGHT

The 10 ectomorphs average a few years older and are significantly taller than the members of the other two groups. Their mean weight, however, is only about one-half that of the endomorphs and 50 pounds lighter than the average for the mesomorphs. As would be expected, these weight means are all significantly different. The weight range for the endomorphs is from 225 pounds to 360 pounds. Even excluding the 360 pounder from the series, the average weight for these mas-

sive physiques is still 246 pounds, a tolerably large figure. Weight range for the mesomorphs is 160 to 202 pounds and for the ectomorphs 114 to 143 pounds.

A comparison with Sheldon's extreme somatotypes shows all three of the present series to average taller and heavier than his 18 year olds. The endomorphs average about 50 pounds heavier than his corresponding group although they are only three years older. The difference of weight means for the two series of ectomorphs, however, is only 10 pounds despite a difference of almost 8 years in mean age.

DISCUSSION OF MEASUREMENTS

It is obvious from table 2 that the endomorphs have the widest heads and faces and the largest lateral, anteroposterior and circumference dimensions of the trunk and extremities. Similarly it is evident that these same dimensions are greatly reduced among the ectomorphs. By virtue of being the tallest this latter group also possesses the longest arms and legs. For the most part the measurement means of the mesomorphs fall in between those of the other two series.

We should like to know, of course, just how different the measurements taken on these three groups are in terms of a statistical test of significance, i.e., are the observed differences of means outside the realm of chance variation? Since the samples are small it was decided to apply the "t" test for each individual measurement in a three-way comparison. The endomorphs are compared with both the mesomorphs and ectomorphs, and the mesomorphs are compared to the ectomorphs. The value of "t" was calculated according to the formula suggested by G. W. Snedecor ('46) for comparison of groups of equal size. The formula for "t" is as follows:

$$t = \frac{\bar{x}}{S} \sqrt{\frac{n(n-1)}{Sx^2}}$$

in which \bar{x} designates the difference between the two group means and Sx^2 the pooled sum of squares. The values of P are derived from tables of "t" as given by R. A. Fisher and

TABLE 2

Means and standard deviations of measurements for the three groups

MEASUREMENT	ENDO		MESO		ECTO	
	Mean	S.D.	Mean	S.D.	Mean	S.D.
Head length	197.6	9.09	199.2	5.53	194.4	5.62
Head breadth	159.6	3.60	157.1	4.04	151.4	4.30
Minimal frontal	112.1	3.53	110.3	3.50	104.9	3.41
Bizygomatic	145.9	4.01	143.6	4.43	137.1	2.61
Bigonial	112.1	4.91	107.9	4.88	103.9	5.28
Face height	125.2	6.60	126.2	5.29	121.7	6.41
Upper face height	71.9	3.72	73.3	4.81	74.2	3.52
Nose height	53.9	3.81	56.2	3.16	57.1	3.87
Nose breadth	39.7	1.42	39.9	2.68	35.1	2.23
Inter pupillary space	66.0	2.38	66.7	2.61	63.6	2.80
Finger length	98.4	5.44	102.0	5.50	103.9	4.51
Hand length	196.8	10.54	194.9	12.44	202.1	7.23
Palm breadth	93.4	5.30	92.5	5.27	87.5	3.92
Humerus length *	29.4	1.78	29.9	1.55	32.7	1.77
Radius length *	26.1	1.74	25.8	1.52	27.5	1.33
Total arm length *	75.2	3.61	75.4	4.11	80.3	3.20
Span *	183.8	8.72	183.3	8.34	188.6	6.20
Femur length *	52.7	2.53	52.6	2.77	57.6	2.23
Tibia length *	38.6	2.15	38.9	3.05	41.9	2.29
Total leg length *	81.0	3.56	80.9	3.75	88.9	4.33
Sitting height *	96.6	3.30	94.3	2.69	94.4	2.92
Trunk height *	64.4	1.94	62.9	2.21	61.6	2.98
Biacromial *	42.1	2.73	41.7	1.74	38.6	1.36
Biiliac *	35.0	3.45	28.3	.75	27.7	1.35
Chest breadth *	33.2	2.61	30.4	1.60	27.0	.94
Chest depth *	25.1	2.60	21.5	2.03	18.1	1.25
Head circumference	587.1	19.99	578.9	11.31	566.5	10.61
Neck circumference	419.9	26.87	394.0	14.90	337.0	11.64
Chest circumference *	118.5	9.73	100.0	5.54	83.7	3.23
Upper arm circ.	366.2	40.25	323.7	25.82	232.0	9.53
Lower arm circ.	304.0	22.96	297.3	15.57	238.1	10.06
Mid thigh circ.	684.8	53.59	583.6	34.02	464.1	21.43
Calf circumference	446.2	36.96	389.2	18.31	326.9	7.57

Note: Measurements marked (*) in centimeters, all others in millimeters.

TABLE 3

Differences of means of measurements and P values for the intergroup comparisons

MEASUREMENT	ENDO/MESO		ENDO/ECTO		MESO/ECTO	
	Difference of means	P *	Difference of means	P *	Difference of means	P *
Head length	— 1.6	.70	3.2	.50	4.8	.10
Head breadth	2.5	.20	8.2	.001	5.7	.01
Minimal frontal	1.8	.50	7.2	.001	5.4	.001
Bizygomatic	2.3	.30	8.8	.001	6.5	.001
Bigonial	4.2	.10	8.2	.01	4.0	.10
Face height	— 1.0	.80	3.5	.40	0.5	.90
Upper face height	— 1.4	.50	— 2.3	.40	— 0.9	.70
Nose height	— 2.3	.20	— 3.2	.10	— 0.9	.60
Nose breadth	— 0.2	.90	4.6	.001	4.8	.001
Inter pupillary space	— 0.7	.60	2.4	.10	3.1	.05
Finger length	— 3.6	.20	— 5.5	.05	— 1.9	.50
Hand length	1.9	.80	5.3	.30	7.2	.20
Palm breadth	0.9	.80	5.9	.02	5.0	.05
Humerus length	— 0.5	.60	— 3.3	.001	— 2.8	.01
Radius length	— 0.4	.70	— 1.4	.10	— 1.8	.02
Total arm length	— 0.2	.90	— 5.1	.01	— 4.9	.01
Span	0.5	.90	— 4.8	.20	— 5.3	.20
Femur length	0.1	.95	— 4.9	.001	— 5.0	.001
Tibia length	— 0.2	.90	— 3.3	.01	— 3.1	.05
Total leg length	0.1	.95	— 7.9	.001	— 8.0	.001
Sitting height	2.3	.20	2.2	.20	— 0.9	.95
Trunk height	1.5	.20	2.8	.05	1.3	.30
Biacromial	0.4	.70	3.4	.01	3.0	.001
Biiliac	6.6	.001	7.3	.001	0.7	.20
Chest breadth	2.7	.02	6.1	.001	3.4	.001
Chest depth	3.6	.01	7.0	.001	3.4	.001
Head circumference	8.2	.30	20.6	.01	12.4	.02
Neck circumference	25.9	.02	82.9	.001	57.0	.001
Chest circumference	18.5	.001	34.8	.001	16.3	.001
Upper arm circumference	42.5	.02	134.2	.001	91.7	.001
Lower arm circumference	6.7	.50	65.9	.001	59.2	.001
Mid thigh circumference	101.2	.001	220.7	.001	119.5	.001
Calf circumference	57.0	.001	119.3	.001	62.3	.001

* P equal to or less than.

F. Yates ('48). The degrees of freedom are $n - 1$ for each series or $20 - 2 = 18$ for the two compared groups. With 18 degrees of freedom the probability of a value of "t" larger than 2.101 occurring by chance is only 5 in 100. The level of significance is usually taken at $P < .05$.

Tables 3, 5 and 7 are presented to show the differences of means of measurements and proportions between the three compared groups and the P values which indicate the probabilities that such differences could occur by chance. A P of .05 means that such a difference could occur by chance only 5% of the time, assuming the null hypothesis.

From table 3 we see that in the comparison of measurements there are 8 instances in which the endomorph means are significantly larger than those of the mesomorphs. These measurements are the following: bi-iliac diameter, chest breadth, chest depth, neck circumference, chest circumference, upper-arm circumference, mid-thigh circumference and calf circumference. Not a single head measurement or linear dimension of trunk or limbs shows a significant difference of means between these two groups.

Turning to the endomorphs versus the ectomorphs we find that the value of P is less than .05 in 24 of the 33 measurements. Thus in 73% of the measurements the differences of means are statistically significant between these two compared groups. The corresponding figure for the endo-meso comparison is only 24%.

In 5 of the 10 head measurements the means of the endo and ecto groups are significantly different. In 6 of 9 length measurements on the extremities, the taller ectomorphs show significantly higher means than the endomorphs. Endomorphs, however, have significantly wider hands than ectomorphs.

All of the endomorph trunk measurements, except sitting height, are significantly greater than those of the ectomorphs. The differences are particularly striking in the circumferences although the differences between the lateral and anteroposterior diameters are also very great indeed.

The meso-ecto comparison shows 22 of 33 measurement means to be significantly different. The mesomorphs possess significantly larger dimensions in 5 out of 10 head measurements, whereas the taller ectomorphs have larger mean values in 7 out of 10 extremity lengths. In the trunk the mesomorphs

TABLE 4
Means and standard deviations of indices for the three groups

INDEX	ENDO		MESO		ECTO	
	Mean	S.D.	Mean	S.D.	Mean	S.D.
Cephalic	80.9	4.07	78.9	3.75	77.9	3.44
Facial	85.8	6.32	87.8	4.02	88.7	4.32
Nasal	74.0	6.32	71.7	5.77	61.9	6.37
Hand	47.3	1.70	47.6	2.22	43.4	1.71
Biiliac/biacromial	83.3	7.35	68.2	3.49	71.7	3.35
Thoracic	75.9	4.77	70.4	4.88	66.8	5.16
Radius/humerus	88.9	4.48	86.1	3.90	84.2	2.97
Tibia/femur	73.3	4.45	73.9	4.15	72.7	3.68
Total arm l./total leg l.	92.5	2.41	93.0	1.41	90.5	2.63
L. arm circ./u. arm circ.	83.5	4.93	92.2	5.27	102.5	4.97
Calf circ./thigh circ.	67.5	5.32	66.7	2.36	70.5	2.17
Total arm l./stature	42.2	1.09	42.9	1.26	43.8	1.27
Span/stature	103.3	2.12	104.6	2.10	103.0	2.24
Total leg l./stature	45.5	1.49	46.2	1.08	48.4	1.41
Sitting ht./stature	54.3	1.06	53.8	1.08	51.6	1.41
Trunk ht./stature	36.2	.84	35.9	.91	33.7	1.66
Biacromial/stature	23.6	1.26	23.8	.76	21.1	.92
Biiliac/stature	19.6	1.66	16.2	.70	15.1	.61
Chest breadth/stature	18.6	1.43	17.4	.97	14.8	.32
Chest depth/stature	14.1	1.29	12.3	1.29	9.9	.62
Chest circ./stature	66.7	5.14	57.0	3.48	45.7	1.15
U. arm circ./stature	20.6	2.09	18.4	1.42	12.7	.61
Calf circ./stature	25.1	1.89	22.2	.82	17.9	.47

are larger than the ectomorphs in 10 out of 13 measurements. As would be expected, however, the greatest differences are found in the circumferences.

The average "t's" for the three intergroup comparisons indicate the relative degree of difference between the three series. The mean "t's" are as follows: endo/meso 1.56, endo/

ecto 4.61 and meso/ecto 3.73. By far the greatest differences, then, are found between the endomorphs and ectomorphs and the least between the endomorphs and mesomorphs.

BODY PROPORTIONS

Since the raw measurements do not appear to show many differences between the endomorphs and mesomorphs except in the trunk it was thought that variations in bodily proportions might reveal certain significant dissimilarities of structure between these two groups. Consequently selected indices were calculated from the measurements and the differences of means subjected to the "t" test. Table 4 presents the means and standard deviations of these indices for the three groups, and table 5 gives the differences of means and the P values.

Again we see that it is in the trunk, particularly the thoracic region, where the greatest differences are to be found between the endomorphs and mesomorphs. Table 5 reveals also that the endomorphs have significantly smaller lower arm girths relative to upper arm circumference and greater upper arm and calf circumferences relative to stature than do the mesomorphs.

In the three-way comparison we find that the endomorphs possess wider bi-iliac diameters in proportion to biacromial diameter than either of the other two groups and in turn the ectomorph mean is significantly greater than that of the mesomorphs. Endomorphs also have relatively deeper chests than do either the mesomorphs or ectomorphs and, in addition, longer radii relative to humerus length than do the ectomorphs.

Ectomorphs possess the most leptorrhine noses and relatively the narrowest hands of all three compared groups. Their arms are shorter in proportion to leg length than is true of the mesomorphs, but their mean calf circumference relative to mid thigh girth is larger than in mesomorphs.

The mean lower arm circumference relative to upper arm circumference is greatest in ectomorphs and smallest in endo-

morphs. The difference of means are significantly different for all three comparisons.

Mesomorphs show significantly higher nasal indices, relatively broader hands and longer arms in proportion to leg

TABLE 5

Differences of means of indices and P values for the intergroup comparisons

INDEX	ENDO/MESO		ENDO/ECTO		MESO/ECTO	
	Difference of means	P *	Difference of means	P *	Difference of means	P *
Cephalic	2.0	.30	3.0	.10	1.0	.60
Facial	— 2.0	.50	— 2.9	.30	— 0.9	.60
Nasal	2.3	.50	12.1	.001	9.8	.01
Hand	— 0.3	.80	3.9	.001	4.2	.001
Biiliac/biacromial	15.1	.001	11.6	.001	— 3.5	.02
Thoracic	5.5	.02	9.1	.001	3.6	.20
Radius/humerus	2.8	.20	4.7	.02	1.9	.30
Tibia/femur	0.6	.80	0.6	.80	1.2	.70
Total arm l./total leg l.	— 0.5	.70	2.0	.10	2.5	.02
L. arm circ./u. arm circ.	— 8.7	.01	— 19.0	.001	— 10.3	.001
Calf circ./thigh circ.	0.8	.70	— 3.0	.20	— 3.8	.01
Total arm l./stature	— 0.7	.30	— 1.6	.01	— 0.9	.20
Span/stature	— 1.3	.20	0.3	.80	1.6	.20
Total leg l./stature	— 0.7	.30	— 2.9	.001	— 2.2	.001
Sitting height/stature	0.5	.30	2.7	.001	2.2	.001
Trunk height/stature	0.3	.50	2.5	.001	2.2	.01
Biacromial/stature	— 0.2	.80	2.5	.001	2.7	.001
Biiliac/stature	3.4	.001	4.5	.001	1.1	.01
Chest breadth/stature	1.2	.05	3.8	.001	2.6	.001
Chest depth/stature	1.8	.01	4.2	.001	2.4	.001
Chest circ./stature	9.7	.001	21.0	.001	11.3	.001
U. arm circ./stature	2.2	.02	7.9	.001	5.7	.001
Calf circ./stature	2.9	.001	7.2	.001	4.3	.001

* P equal to or less than.

length than do the ectomorphs. The mean lower arm circumference relative to upper arm girth is significantly greater in mesomorphs than in either of the other two groups. It should be pointed out that this is the only instance in this series of indices where a mesomorph mean significantly surpasses an endomorph mean.

MEASUREMENTS IN PROPORTION TO STATURE

When the mean statures of two series of subjects are significantly different, this fact should be taken into consideration in appraising likeness or dissimilarities of measurements taken on various segments of the body. In the present instance the average stature of the endomorphs and mesomorphs is very nearly the same, consequently raw measurement means can be compared directly and no particular benefit may be derived by calculating them as proportions of stature. The ectomorphs, however, are significantly taller than either of the other two groups. For this reason there is considerable justification for calculating the measurements in terms of stature before attempting to compare the respective means values. Actually there are not many instances in this study where specific raw measurement means are significantly different between two of the groups and fail to attain this status when they are compared as proportions to stature, or the reverse. Sitting height, however, may be cited as one example. Table 3 shows that there are no significant differences of means for this measurement when all of the three series are compared, but in proportion to total body height (table 5) the ectomorphs are found to have significantly shorter average sitting heights than either of the other two groups.

PHOTOGRAMMETRY

Since in this study we are seeking to determine just how different these extreme somatotypes are in terms of body measurements it was decided to include the anthropometry made on the photographs in the manner described by Sheldon. These measurements were originally selected because they appeared to be particularly valuable for differentiating between the components of the somatotype. All of these measurements are calculated as proportions to stature.

Table 6 presents the mean measurement-stature ratios for the 17 dimensions, and table 7 gives the differences of means and the P values for the intergroup comparisons.

TABLE 6

Means and standard deviations of photograph measurement-stature ratios

MEASUREMENT-STATURE RATIO	ENDO		MESO		ECTO	
	Mean	S.D.	Mean	S.D.	Mean	S.D.
Facial breadth 1	9.20	.25	8.76	.32	8.09	.30
Facial breadth 2	8.64	.38	8.09	.16	7.15	.31
Neck thickness a-p	7.88	.45	7.03	.53	6.00	.22
Neck thickness transverse	7.82	.50	7.55	.46	6.22	.38
Trunk breadth 1	22.50	1.33	23.76	1.79	18.80	1.08
Trunk breadth 2	20.50	1.16	17.44	.76	14.20	.78
Trunk breadth 3	24.65	1.68	20.34	.92	18.00	.46
Trunk thickness 1	15.64	1.46	13.60	.82	11.02	.45
Trunk thickness 2	18.02	1.89	12.22	1.26	10.16	.54
Trunk thickness 3	18.28	1.61	14.62	1.15	11.80	.37
Arm thickness upper	9.48	.97	8.13	.63	5.58	.46
Arm thickness lower 1	6.16	.40	6.18	.54	4.60	.51
Arm thickness lower 2	4.70	.30	4.47	.20	3.56	.19
Leg thickness upper 1	15.08	1.55	12.04	.82	9.14	.58
Leg thickness upper 2	9.36	.74	8.15	.48	6.56	.21
Leg thickness lower 1	8.20	.56	7.37	.27	5.92	.26
Leg thickness lower 2	4.30	.39	3.70	.23	3.13	.11

TABLE 7

Differences of means and P values for the intergroup comparisons in photograph measurement-stature ratios

MEASUREMENT-STATURE RATIO	ENDO/MESO		ENDO/ECTO		MESO/ECTO	
	Difference of means	P *	Difference of means	P *	Difference of means	P *
Facial breadth 1	0.44	.01	1.11	.001	0.67	.001
Facial breadth 2	0.55	.001	1.49	.001	0.94	.001
Neck thickness a-p	0.85	.01	1.88	.001	1.03	.001
Neck thickness transverse	0.27	.30	1.60	.001	1.33	.001
Trunk breadth 1	1.26	.10	3.70	.001	4.96	.001
Trunk breadth 2	3.06	.001	6.30	.001	3.24	.001
Trunk breadth 3	4.31	.001	6.65	.001	2.34	.001
Trunk thickness 1	2.04	.01	4.62	.001	2.58	.001
Trunk thickness 2	5.80	.001	7.86	.001	2.06	.001
Trunk thickness 3	3.66	.001	6.48	.001	2.82	.001
Arm thickness upper	1.35	.01	3.90	.001	2.55	.001
Arm thickness lower 1	0.02	.95	1.56	.001	1.58	.001
Arm thickness lower 2	0.23	.10	1.14	.001	0.91	.001
Leg thickness upper 1	3.04	.001	5.94	.001	2.90	.001
Leg thickness upper 2	1.21	.001	2.80	.001	1.59	.001
Leg thickness lower 1	0.83	.001	2.28	.001	1.45	.001
Leg thickness lower 2	0.60	.001	1.17	.001	0.57	.001

* P equal to or less than.

In the endo-meso comparison there are only 4 instances where the differences of means do not reach the level of statistical significance ($P = .05$). These are the transverse thickness of the neck (NTt), upper trunk breadth (TB 1), maximum thickness of the lower arm (ATL 1) and the transverse wrist diameter (ATL 2). The differences of means for all the other ratios are significant to a very marked degree. Similarly all 17 differences of means in the endo-ecto and meso-ecto comparisons are statistically significant as revealed by the "t" test. The average "t" values for the three intergroups comparisons are as follows: endo-meso 4.14, endo-ecto 10.54 and meso-ecto 7.99.

DISCUSSION

The subjects in this report were selected for study on the basis that each one exhibited in his morphology characteristics which are typical of the extreme manifestations of one of the components recognized in Sheldon's somatotyping system. We start, then, with groups of individuals who are easily recognizable anthroposcopically as extreme variants of the human physique. The problem is to show just how different these several groups are in terms of anthropometric measurements and to determine on the basis of our findings, which measurements are most useful for differentiating between different somatotypes.

Students of somatotyping have long been aware of the difficulty of demonstrating the difference between dominance in endomorphy and mesomorphy by measuring the body. As Sheldon points out, almost all diameter measurements clearly differentiate ectomorphy from the other two components, for as ectomorphy rises nearly all diameter measurements fall sharply. The great challenge lies in finding those measurements which will discriminate between the first component, which corresponds to a central concentration of mass, and the second component which reflects a relatively even distribution of mass and thickness of structure even at the peripheries and extremities of the organism. These differences in morphology

are easily discernible to the trained eye but are difficult to demonstrate by a small number of fixed linear measurements. Unfortunately, calipers cannot see.

Anthropologists have frequently asked if somatotyping could be done by anthropometry alone. The answer, of course, is no. Somatotyping is a method of describing the physique in terms of components of structure. It is concerned with asaying relative amounts of muscular development and fatty deposits, the shape and contours of all portions of the body, the hardness, softness and delicacy of structure. Measurements may be useful as supporting evidence but they can never take the place of describing what the eye sees.

The results of this anthropometric survey of extreme somatotypes indicate several things. For the most part measurements of the head and face, even for the extreme somatotype, do not differentiate between endomorphy and mesomorphy but do distinguish ectomorphy from these two. Most of these measurements are diameters and thus differentiate between linearity and laterality. Length measurements of the face show no differences between the three compared groups.

Length measurements on the extremities emphasize the linear characteristics of ectomorphs but again do not differentiate even between extreme endomorphy and mesomorphy. Limb segments of the ectomorphs are both absolutely long and long relative to stature.

Trunk length measurements serve to emphasize the relative shortness of this bodily segment in ectomorphs. Both endomorphs and mesomorphs appear to possess fairly long trunks. In somatotyping, the long trunk has usually been associated with the mesomorphic physique. The rather high values for sitting and trunk height in our groups of extreme endomorphs may be due in part to the thicker fatty deposits on their buttocks.

Lateral diameters of the trunk differentiate to a certain extent between endomorphy and mesomorphy. Both groups possess broad shoulders but the biiliac dimension of endomorphs far exceeds that of mesomorphs. Mesomorphs char-

acteristically have broad shoulders and proportionately narrow hips. Relative to stature, however, their hips are broader than those of the ectomorphs.

Chest breadth and chest depth dimensions are greater in endomorphs than in mesomorphs and both these groups have larger chests than ectomorphs. Endomorphs, however, are relatively deep chested whereas mesomorphs and ectomorphs are flat chested.

So far as diameter measurements are concerned those of the trunk serve fairly well for differentiating between the first two components in extreme somatotypes. No single dimension, however, will suffice by itself. It is only by considering several such measurements together that one can distinguish between the morphological characteristics of endomorphy and mesomorphy.

It is in the circumference measurements where we find the greatest differences between the endomorphs and the mesomorphs. This is not surprising since we know that the former group weighs on the average 70 pounds more than the latter. Nevertheless, the high level of statistical significance for the differences of means of these measurements indicates their predictive value for differentiating between the components possibly in the midrange as well as in extreme somatotypes.

All the circumference measurements of endomorphs average larger than those of the other two groups. The differentiation between endomorphy and mesomorphy is not always revealed, however, by one girth measurement alone, but often becomes evident only when two or more are considered together. The mean lower arm girth, for example, is about the same for these two groups but when calculated as a proportion to upper arm circumference the mean ratio differences are great.

The results of this study show that there are great anthropometric differences between the more massive extreme endomorphs and mesomorphs on the one hand, and the slender ectomorphs on the other hand. These findings are *a priori* what one would expect. We are forced to conclude, however,

that the differences in the measurements on these extreme somatotypes are not sufficiently great to suggest that similar measurements would suffice to distinguish between less extreme body builds, such as the midrange somatotypes, or between closely related somatotypes. Possibly a few trunk diameters and circumferences might differentiate to a certain extent between less extreme physiques but for the most part standard anthropometric measurements cannot be substituted for the anthroposcopic techniques employed in somatotyping. As Sheldon has demonstrated, the nearest approach to a useful anthropometry for somatotyping is the series of measurements he devised which are taken on the films of the standard somatotype photographs.

SUMMARY AND CONCLUSIONS

Anthropometric measurements were taken on 30 extreme somatotypes. In the group were 10 endomorphs, 10 mesomorphs and 10 ectomorphs. The comparison of measurement means showed the ectomorphs to be extraordinarily different from the other two groups. Differences between the endomorphs and mesomorphs occurred mainly in trunk diameters and circumferences.

Results indicated that head and face measurements and body and limb lengths failed to differentiate well between the three groups of extreme somatotypes. Lateral and antero-posterior diameters of the trunk, and circumference measurements showed greater differences. They were not so successful, however, as Sheldon's needle point measurements on the photographs for discriminating between morphological types. The conclusion is reached that anthropometric measurements on the living are only moderately successful in demonstrating anatomical differences between extreme somatotypes and are of questionable value in differentiating between the midrange and closely related somatotypes.

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PLATE 1

EXPLANATION OF FIGURES

Examples of somatotypes measured in this study. Top, extreme endomorph; middle, extreme mesomorph; bottom, extreme ectomorph.





DR. ERNANI MARTINS DA SILVA, a contributor of two articles to this Journal (vols. 6, 7) died recently in Brazil. Dr. da Silva was born in Diamantina, state of Minas, Brazil, March 3, 1914, obtained his medical training under the Faculty of Medicine, Rio de Janeiro, and then joined the staff of the Instituto Oswaldo Cruz. He specialized in hematology and blood parasites.

When Dr. da Silva sent in his first manuscript to the Journal in 1947, the Editor called his attention to the unusually high proportion of blood group B reported by Rahm for the Carajá Indians, and suggested that this work should be repeated. Under date of January 21, 1948, Dr. da Silva replied as follows:

Dr. Henrique Aragão, director of the Instituto, and Dr. Walter Oswaldo Cruz, chief of the Department of Hematology, have become very much interested in the study of the blood groups of the Carajá Indians which you suggested. We plan an expedition to the Araguaia Valley and Bananal Island next March. I plan to investigate the following points: (1) ABO blood groups, M, N and P factors; (2) Rh types; (3) sickle cell anemia; (4) a survey of food in relation to hemoglobin levels; (5) acculturation and mixture as reflected by the blood groups; (6) color pictures of full-blooded Indians and mixed types, with films of the most important cultural traits. I believe that this study will be a little more comprehensive than that carried out in the Mato Grosso. I am writing to Dr. Wiener and Dr. Levine in order to obtain the Rh, M, N and P sera. Although it is now very difficult to send money to the United States, I hope to get the sera.

According to the reports reaching this country, Dr. da Silva was drowned in the Araguaia River during his work on the Carajá Indians.

AN ASSOCIATION BETWEEN TYPE OF WORK AND PHYSIQUE IN AN INDUSTRIAL GROUP¹

STANLEY MARION GARN² AND MENARD M. GERTLER³

Coronary Research Project, Massachusetts General Hospital

ONE FIGURE

A number of recent studies have shown that college undergraduates grouped on the basis of physique showed differences in interests and in intended vocations. Conversely, students grouped on the basis of field of undergraduate concentration, preferred occupation, or intended vocation showed group differences in physique. Such studies are those of Sheldon ('40, '45), Hooton ('45), Morris ('48), Heath ('45), and Seltzer ('45, '48). Seltzer ('45) has further demonstrated that more muscular, more "masculine," students showed preferences for engineering, business, and the natural sciences; while the less muscular, less "masculine" students preferred the humanities, the social sciences, and the arts. Woods et al. ('43) considered physique to be important in predicting the suitability of an individual for officer training in the armed services.

Although these physique-occupation associations seem to be well demonstrated at the undergraduate level, there is less in-

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formation available on the physique-occupational associations of individuals older than college students, or not undergoing undergraduate training. The major contribution to our knowledge of such associations is Hooton's ('48) extensive statistical study of the relation between army occupation and physique. He points out, however, that the individual's army occupation depends more on the judgment of others than on the preferences of the individual himself. It is of interest, therefore, to determine whether such relationships exist when occupational choice is more subject to the preferences of the individual.

An opportunity to establish such a relationship appeared during the course of medical and anthropometric studies on an industrial group of "older" adult males. The present communication, representing one part of this study, contrasts the physique and measurements of a group primarily engaged in research with a general factory group.

MATERIAL AND METHODS

As a part of a study of the morphology and biochemistry of the healthy older working male, 100 men between the ages of 19 and 54 were given detailed anthropological and medical examinations. These men were all employed in the plant itself (not in executive or planning capacities), but out of the total a sub-group of 20 were actively concerned with research, either as scientific workers or technical assistants. Since the general plant group corresponded closely to the research sub-group both as to age and racial origin, it was felt that comparisons of the sub-group with the total group could be made without allowances for these factors.

Both the anthropometric and somatotype techniques followed the standardized methods, and measurements were made on the nude subjects in every case. Anthropometric measurements followed Martin ('28) and Hooton ('46) and the methods were those of the Harvard anthropometric laboratory. Further, to differentiate breadth and depth measurements for use in body-build studies, certain non-standard

measurements were borrowed from recent wartime anthropometric surveys; they are specially indicated on the tables.

The somatotype studies followed the methods of Sheldon ('40) as closely as possible, although no standards were available for this age group. Because of the 25 year age range, we were interested in removing — as far as possible — the effects of age from our ratings. Therefore, the height-weight ratio was not used as a fixed criterion (see Sheldon, '40, p. 266), and less attention was paid to exclusively abdominal fat deposits. That we have achieved a rating system relatively free from age influences is shown by the negligible correlation of $+.04 \pm .08$ between age and endomorphy, $-.03 \pm .07$ between age and mesomorphy, and $-.06 \pm .08$ between age and ectomorphy. It is reasonable, then, to assume that our rating system is uninfluenced by age.

All tests of statistical significance were made by comparing the research sub-group to the total plant group including that sub-group. This was done in order to test the assumption that the differences exhibited by the research sub-group were due to sampling error, and this comparison is to be considered a most rigorous test.

RESULTS

Physique. The research sub-group differed significantly from the total group, showing more dominant ectomorphy, less dominant endomorphy, and less dominant mesomorphy. As shown in table 1 the largest physique group in the plant as a whole comprised the dominant endomorphs, with reasonably large representations of dominant mesomorphs, dominant ectomorphs, and mid-range physiques. On the other hand, the research men showed a maximum of dominant ectomorphs, with mid-range physiques next in order, and far lower percentages of dominant endomorphs and dominant mesomorphs. Combining mid-range physiques and dominant ectomorphs, 70% of the research men had moderate to high ectomorphy, compared to 40% of the total factory group. The outstanding difference, then, was in the strength of the third component.

These groupings by dominances were checked by comparing the mean component ratings and the modal component ratings. The mean component ratings for the research men were: endomorphy $3.2 \pm .21$, mesomorphy $3.4 \pm .22$, and ectomorphy $4.2 \pm .19$. The comparable means for the total plant group were $3.8 \pm .15$, $3.95 \pm .11$, and $2.89 \pm .17$. The modal component ratings were 3, 3, and 4 for the research men, and 4, 4, and 3 for the plant group as a whole. The differences between the mean component values for the two groups are all significant; the critical ratios of the differences of the three components being 2.4, 2.29, and 5.24, respectively. Again, the

TABLE 1
Physique breakdown by somatotype dominances (percentages)

	RESEARCH (N = 20)	PLANT (N = 100)
	%	%
Dominant endomorphs	10	28
Dominant mesomorphs	10	17
Dominant ectomorphs	45	23
Mid-range physiques	25	17
Balanced endo-mesos	5	12
Balanced ecto-endos	5	3
	100	100

greatest difference is in ectomorphy; the magnitude of the difference being equal to one standard deviation.

As would be expected for a group showing greater ectomorphy, the research group showed a higher ponderal index. The ponderal index was $12.9 \pm .12$ for the research sub-group as compared to $12.4 \pm .06$ for the plant group; the difference is significant at the 1% level.

Since the major study was concerned with morphology in health and disease, the degree of "overweight" was determined for each individual in the series in the manner described by Levy, White, Stroud and Hillman ('46) as a deviation from the weight value calculated for age and height from the Army 40-105 age-height-weight standards. The mean deviation from

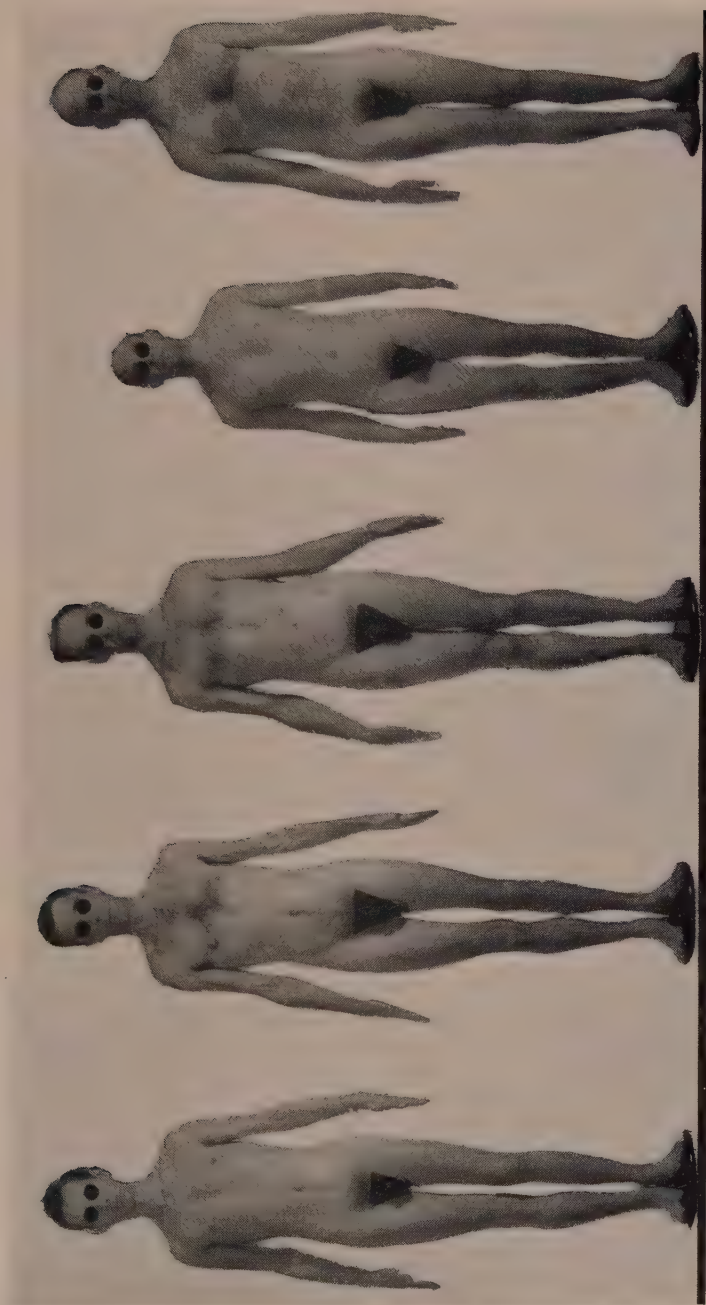


Fig. 1. Ectomorphic physiques among the research group. From left to right the ages and ponderal indices are 27 and 13.9, 33 and 14.2, 31 and 13.1, 37 and 12.9, and 42 and 13.4. Compare with the ponderal indices of ectomorphic college age students reported by Seltzer ('48).

the calculated values for the research group was + 5 lbs. compared to + 20 lbs. in the total plant group. Thus, absolute weight, the ponderal index, and weight against calculated weight, all substantiated the impression of greater ectomorphy in the research group. Photographs of 5 members of the research group are shown in figure 1 as visual evidence of our ratings.

Measurements. The measurements of the two groups are compared in table 2. As shown, the mean age of the research group was 33.3 ± 1.2 , and the general plant group $35.2 \pm .58$, at the time of the examination. The difference (1.9 years) is not statistically significant, and the two groups were considered to be highly comparable in age.

Anthropometrically, the research sub-group differs from the total group in both length and breadth measurements with the research men exhibiting generally elevated length dimensions and generally diminished lateral dimensions. Seven of the measurements can be called length measurements — stature, span, nose length, upper face length, total face length, hand length, and head length. In all of these the research men exceed the general group. In stature and nose length the difference is significant, while in hand length it is nearly significant. There are 15 measurements that can be called breadth measurements. In 13 of these the research men are smaller than the general group; 4 of these differences are significant and 2 others nearly significant. The greater linearity of the research group shows itself also in wrist and hand measurements, and nose measurements, and is especially marked in both of the chest depths and waist breadth. The latter combination would, in itself, suggest that the research men are not only less mesomorphic but less endomorphic as well.

The indices also portray the difference between the groups. The ponderal index is higher in the research group, and the research men tend to have relatively flatter chests, narrower waists compared to hips, relatively narrower noses, relatively narrower shoulders, and relatively narrower faces. Of the 9

TABLE 2

Anthropometric comparison — Plant group and research group

MEASUREMENTS	MEAN \pm STANDARD ERROR		DIFFERENCE (II - I)	SIGNIFICANCE RATIO ¹
	Plant (I)	Research (II)		
1 Age	35.2 \pm .58	33.3 \pm 1.2	- 1.9	1.2
2 Weight (lbs.)	176.6 \pm 2.6	167.2 \pm 5.3	- 9.4	1.6
3 Usual weight (lbs.)	171.5 \pm 2.3	163.5 \pm 5.1	- 8.0	1.4
<i>Length measurements</i>				
4 Stature (cm)	176.9 \pm .7	179.3 \pm 1.1	+ 2.7	2.05 ¹
5 Span (cm)	180.6 \pm .8	182.4 \pm 1.5	+ 1.8	1.1
6 Nose length	56.3 \pm .4	58.4 \pm .6	+ 1.9	3.0 ¹
7 Upper face length	69.4 \pm .5	72.0 \pm 1.2	+ 2.6	2.0 ¹
8 Total face length	123.9 \pm .7	125.0 \pm 1.6	+ 1.1	.7
9 Hand length	193.8 \pm .8	195.8 \pm 1.4	+ 2.0	1.9
10 Head length	194.8 \pm .8	196.4 \pm 1.3	+ 1.6	1.1
<i>Breadth measurements</i>				
11 Shoulder breadth (cm)	40.6 \pm .2	40.0 \pm .7	- .6	.86
12 Chest breadth (cm)	30.5 \pm .2	28.9 \pm .5	- 1.6	3.1 ¹
13 Waist breadth (cm) ²	29.7 \pm .2	27.9 \pm .4	- 1.8	3.5 ¹
14 Hip breadth (cm)	30.3 \pm .2	29.6 \pm .4	- .7	1.5
15 Upper chest depth (cm) ²	19.1 \pm .2	17.7 \pm .4	- 1.4	3.3 ¹
16 Chest depth (cm)	22.9 \pm .3	21.2 \pm .6	- 1.7	2.7 ¹
17 Sternum ensiform (cm) ²	23.4 \pm .2	22.4 \pm .5	- 1.0	1.1
18 Bipupillary	65.1 \pm .3	64.2 \pm .7	- .9	1.2
19 Nose breadth	36.6 \pm .3	35.5 \pm .6	- 1.1	1.8
20 Wrist breadth	59.3 \pm .3	58.6 \pm .7	- .7	.9
21 Hand breadth	88.6 \pm .5	87.5 \pm .8	- 1.1	1.2
22 Biocular	107.4 \pm .5	107.6 \pm .6	+ .2	.3
23 Bizygomatic	141.0 \pm .6	140.1 \pm 1.3	- .9	.6
24 Bigonial	107.9 \pm .5	107.6 \pm .7	- .3	.3
25 Head breadth	153.7 \pm .6	154.6 \pm 1.5	+ 1.1	.6
<i>Indices</i>				
26 Ponderal index (Ht. Wt.)	12.4 \pm .1	12.9 \pm .1	+ .5	3.1 ¹
27 Thoracic index (16/12)	74.7 \pm .7	72.6 \pm 1.5	- 2.1	1.3
28 Relative span (5/4)	102.5 \pm .3	101.8 \pm .5	- .7	1.2
29 Hip-shoulder (14/11)	75.2 \pm .4	74.7 \pm 1.3	- .5	.4
30 Waist-hip (13/14)	97.6 \pm .5	93.4 \pm .9	- 4.2	4.2 ¹
31 Upper face (7/23)	50.4 \pm .6	51.5 \pm 1.0	+ 1.1	1.0
32 Eye face (18/7)	94.5 \pm .8	89.6 \pm 1.5	- 4.9	2.9 ¹
33 Nasal index (19/6)	64.6 \pm .6	61.0 \pm 1.3	- 3.6	2.6 ¹
34 Relative shoulder breadth (11/4)	23.7 \pm .1	22.5 \pm .3	- 1.2	2.8 ¹

¹ Values starred when ratio equals 2 or greater (note 2 S.E. = 3 P.E. When XSE = 2, $p = .05$, when XSE = 3, $p = .01$).

² Non-standard measurements.

indices used here, 5 differences are statistically significant at better than the 2% level. The indices thus confirm the impression that the research men are comparatively flattened and elongate.

It is interesting to note that of 10 measurements of the head and face, differences are significant in only 2 cases, while 5 out of 13 body measurements show significant differences. Thus, in this study the groups differ more distinctly in the body than in the head, though the research men do tend to longer and narrower heads and faces.

DISCUSSION

Both the anthropometric measurements and the somatotype ratings show that the research group is more elongate, more compressed antero-posteriorly, and narrower, than the total plant group. Again in this study, as Seltzer ('46) pointed out, differences in physique are more apparent when the somatotype ratings are compared than when the measurements are compared.

We have indicated that the greater degree of ectomorphy shown by the research group cannot be due to the masking effect of age, for within the limits of this group our rating system appears to be uninfluenced by age; furthermore, the plant and research groups are nearly identical in mean age. Since both groups are largely of Old American and Northwest European origin with only a minimum Southern European element, the physique difference cannot be attributed to racial factors.

One further possibility remains to be considered: that we are dealing with a physique difference actually associated with economic position and education, since many of the research group are college-educated. This possibility has been eliminated to some extent by comparing the research group and the plant group to the somewhat older executive group of 47 men, with a mean age of 42 years: this executive group is also largely college trained. Despite the difference in age, we found few statistically significant differences in measurement be-

tween the plant and executive group, while the differences between the executive and research groups were of a slightly greater order of magnitude than the differences between the research and total plant groups. We therefore assume that the physique difference in question is not a function of college training alone.

It is likely, then, that the greater representation of ectomorphs in the research group is due to factors other than chance, age influence on rating, education, or racial origin.

The first explanation may be entirely physical. The general plant group included manual laborers, firemen, assembly workers, and foremen (occupations physically incompatible with ectomorphy), whereas research does not place a premium on physical strength. However, the distinction between the routinized, competitive activities in the plant proper, and the non-routinized more cerebralized flavor of the research department suggests that temperamental correlates of ectomorphy may be active in the association.

While some of the temperamental concomitants of ectomorphy as related by Sheldon ('45), such as poor routinization, inhibited address, and hyperresponsiveness would be liabilities in the other occupations mentioned, they may not be detriments in research. Furthermore, the demonstration by Seltzer that mesopenic ectomorphs lack the direct, pragmatic somatotonic approach is pertinent; these qualities, the "bull in a china shop" approach, may be useful on a managerial level but not in research. The occupation-physique relationship here appears to turn upon the question of the temperamental component *cerebrotonia*, and upon this point Seltzer ('48) has recently confirmed Sheldon's ('45) correlation, by classifying up to 84% of the dominant ectomorphs in the Grant Study as cerebrotonics. Within this research group, at least, cerebrotonia may be an asset to research. However, the findings in this case should not be applied to research groups in general without further study.

SUMMARY

A group of 100 healthy older employed men in an eastern factory, with a mean age of 35.2 years was compared to 20 members of that group, with a mean age of 33.3 years, primarily engaged in research. Though not significantly different in age, racial origin, or economic status, the two groups differed significantly in physique (somatotype distribution) and in measurements. All three Sheldonian components showed significant mean differences. The principal difference was in ectomorphy: 45% of the research men and only 23% of the total group were rated as dominant ectomorphs. Anthropometric measurements showed that the research men were more elongate, more flattened, and narrower; 12 out of 34 measurements and indices exhibited statistically significant differences. The somatotype system showed the differences more graphically than did the anthropometric presentation. Since other factors were ruled out, it was suggested that the selection for ectomorphy was partly on the basis of minimum strength requirements in this research group, and largely on the basis of the temperamental correlates of ectomorphy that may be liabilities in certain other occupations, but are possibly assets in research. It is not suggested that the association has universal application.

ACKNOWLEDGMENT

The authors wish to thank Mrs. Jennifer Lehmann, research assistant, Coronary Research Project, for her statistical assistance in this work.

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QUANTITATIVE PROBLEMS IN INHERITANCE.—The genes referred to in most of the above discussion are such as to give sharply recognizable differences. It should however be remembered that most of the gene differences prevalent in populations, distinguishing individuals phenotypically, only affect, at least as the end product of their action, the quantity of some character or characters. Usually the effect is also modified by the action of environmental conditions and of an undetermined but often large number of other, coacting gene differences, not readily distinguishable from them. We are thereby confronted with problems of multiple gene inheritance. For their study, in the absence of definitive signs of the individual genes, an approach combining the principles of Mendelian inheritance with the methods of statistics adapted to the latter are necessary. Through these means, although the genetic composition of the individuals themselves remains largely undetermined, nevertheless progress can be made towards predicting in a general way the probable results to be expected from given types of crosses.

One of the objectives in such work must be the obtaining of evidence concerning the relative frequencies, in the population, of gene differences having different degrees of effect on the given character — i.e., a frequency magnitude of effect distribution. Other objectives are to gain evidence as to degrees and direction of dominance shown by the gene differences of different magnitude, and as to the extent to which the effects may be treated as simply (logarithmically) cumulative or, contrariwise, as embodying more specialized types of interaction with each other and with environmental effects. Nor can the answers for one type of character, such as stature, or for one population, such as West Europeans, be carried over without verification to another character, such as head-shape, or to another population, such as Eskimos.

Now it might be thought that in prosecuting such studies we are passing over from characters of medical interest to those which concern more purely the physical anthropologist. However, there is no fundamental distinction between gene differences of the more extreme and usually rarer kind and those of the less extreme and usually commoner kind; they grade imperceptibly into each other. Although the primary gene effect is probably in the vast majority of cases a qualitative chemical one, studies on lower forms show that it usually expresses itself through its quantitative influence upon some chemical process concerned with development or physiology, even when the final outcome again appears as a qualitative difference. And so the cumulative action of a number of minor differences that happen to work in the same direction may be as great as, and very similar to, the action of one "large mutation." To know how often to expect effects of different degrees, then, from given types of matings, we should know the frequency distribution of the gene differences of different magnitudes. Vice versa, the latter may to a certain extent be estimated from data concerning the former. But as yet there has been little attack upon these difficult problems. Their very formulation shows us, however, that there is no sharp category of "abnormal" versus "normal" variants. And medicine and even psychology, along with anthropology, will increasingly have to take the so-called "normal variations" into consideration in their judgments concerning diagnosis, prophylaxis and treatment.—II. J. Muller. Progress and prospects in human genetics. *Am. J. Human Genetics*, vol. 1, pp. 1-18.

AGE CHANGES IN HEAD HAIR FROM BIRTH TO MATURITY ¹

II. MEDULLATION IN HAIR OF CHILDREN

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FIVE FIGURES

In the first publication of this series (Trotter and Duggins, '48), data on the index and size of children's hair were presented. It was pointed out that 16 White children of American parentage, 9 girls and 7 boys, have provided head hair specimens (from the vertex) monthly since birth for examination. The oldest, subject A, is now 18 years of age and the youngest, subject P, is 6 years of age. There are 5 pairs of siblings among the contributors. One pair, subjects L and M, are identical twins. The plan is to continue receiving hair specimens from the 16 subjects until each is 25 years of age. It is contemplated that representative samples of hair for each year from each individual will be examined with reference to all physical and microscopic characteristics.

It has generally been agreed by previous investigators that the presence or absence of a medulla in head hair has little significance (Kirk, '40), and that there is no correlation between medullation and age (Wynkoop, '29). According to Hausman ('30) the presence or absence of a medulla, as well as its type, is in direct agreement with the diameter of the hair shaft, the largest hairs presenting continuous medul-

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las most frequently. Danforth ('25) has said that the fine and silky hair of childhood contains considerable pigment but no medulla; that the coarser hair of children usually contains no medulla, but that occasionally an interrupted or even continuous medulla may be encountered. The present investigation was undertaken to determine the incidence and type of medullation and its relation to size of the hair from birth to 14 years of age in a group of 16 children.

MATERIAL AND METHOD

Hair specimens, taken at birth or shortly thereafter, were available from 12 of the 16 subjects. Subject G contributed his first specimen at one month. Subjects L and M did not furnish their first samples until three months of age, whereas, subject J, began contributing at one year. Following the submission of the first specimen, monthly samples of hair have been received from each subject with very few exceptions.

Each sample for the first 7 months, containing 50 to 300 hairs, was examined. After the first 7 months, however, 25 unselected hairs were taken from each sample at 6-month intervals. Thus, 50 hairs were observed for each year from each subject: 25 from the 1-year-1-month sample, and 25 from the 1-year-7-month sample; 25 from the 2-year-1-month sample, and 25 from the 2-year-7-month sample, etc. Statistical data are presented in this paper only up to 14 years since only 4 of the contributing subjects are presently beyond that age.

In addition, 25 hairs from each of 15 part or full term fetuses were observed. Eight Negro and 7 White fetuses ranging from 4 to 9 months' gestation constituted this group.

Each hair shaft was examined throughout its length under the low power of the microscope at approximately $\times 100$ magnification. Medullas were recorded under 1 of 4 classifications: (1) absent, (2) scanty, (3) broken and (4) continuous (Wynkoop, '29). A medulla classified as scanty is one in which the medullary masses occur at widely spaced in-

tervals along the center of the hair shaft. A broken medulla presents the medullary material grouped together in large segments, whereas the continuous medulla is an unbroken column of dried and cornified epithelial cells. The data on hair size were obtained from the first paper in this series pertaining to index and size of children's hair, since hairs from the same samples were used in both studies. The figure indicated at each interval for size is the total area of 100 hairs for that particular subject for that year. To illustrate, at one year the area of 100 hairs from each of the 15 subjects was determined, thus a total of 1,500 hairs were measured for each year.

INCIDENCE OF MEDULLAS

No evidence of a medulla was found in any hairs of the White fetuses. Many well-developed, broken and continuous medullas, however, were found in three of the full term Negro fetuses. Three additional full term Negro fetuses exhibited no trace of a medulla.

The hair of the 16 living subjects revealed that during the first 7 months, each of the individuals could be placed in one of two categories on the basis of medullation. The first group, subjects M, O and P, presented hair with no medullation. (No hair was available for subject J during the first 7 months.) The second group consisted of the remaining 12 subjects in which the pattern was much the same: during the early months all of the hairs from each of these individuals was quite fine and heavily pigmented with no medulla; suddenly a marked change occurred and the hair, which had been fine, heavily pigmented and non-medullated, was replaced in the next monthly sample by hair which was coarser, exhibited little pigment, and contained fragmentary and broken but nevertheless well-defined, medullas in 50% or more of the samples (figs. 1a, b). In subject C, this transition produced many of the continuous type of medullas at 6 months of age. The month during which the metamorphosis occurred varied among the 12 subjects in which it was noted. The two subjects, B and F, exhibited the transition in the

third month; C, in the 4th month; N, in the 5th month; D, E, G, H, in the 6th month; and A, I, K, L, in the 7th month. Although the change in some subjects was more pronounced than in others, it was sufficiently marked in each subject to be easily recognized. The percentages of hairs, for each

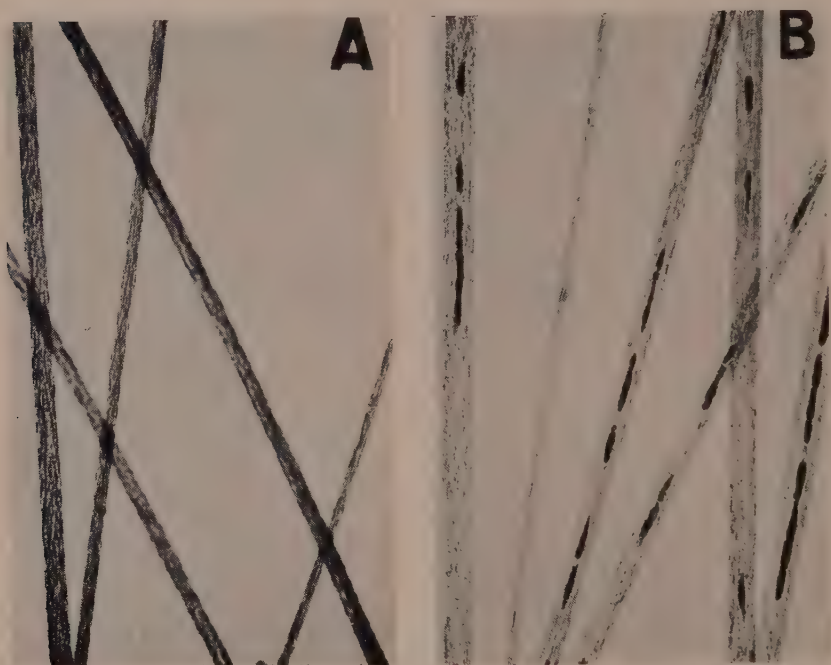


Fig. 1 A, Hair from subject F at two months, showing fine texture, heavy pigmentation and no medullation. $\times 80$. B, Hair from subject F at three months, showing coarser texture, less pigmentation and broken medullas. $\times 80$.

child, which were found to contain medullas during the first 7 months, are summarized in table 1.

It was found that 29 or 1.4% of the 2,052 hairs available at birth, from 11 subjects, contained medullas. At one month of age only 0.7% of the specimens exhibited any sign of medullation. At two months just one medulla was found among the 1,819 hairs examined. All of the 38 medullas

located in the 5,019 hairs taken from the birth, one-month and two-month samples, were extremely fragmentary.

By three months of age, 6% of the specimens contained medullas, many of which were quite distinct and of the broken variety. At 4 months the percentage increased slightly to 6.4%, whereas for the 5th month the figure stood at 10.8%. A marked increase occurred after the 5th month with 34% of the 6-month specimens and 33% of the 7-month specimens exhibiting many broken and even a few continuous medullas. The percentage of medullas present during each month for the first 7 months for 15 subjects is shown in figure 2.

TABLE 1

Percentage of hairs in each monthly sample containing medullas

AGE IN MONTHS	SUBJECTS														
	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O P
B	0	11	0	0	0	0		0	0		0			7	0 0
1	0	4	0	1	0	0		0	0		0			10	0 0
2	0	0	0	1	0	0	0	0	0		0			0	0 0
3	0	47	0	7	0	42	0	0	0		0			4	0 0
4	0	9	41	14	0	41	0	0	0		0	0	0	0	0 0
5	0	4	27	3	0	80		0	0		0	0	0	84	0 0
6	0	59	65	53	59	13	53	62	8		11	0	0	68	0 0
7	28	25		43	59	34	96	51	54		85	79	0	61	0 0

Following the 7th month, 25 hairs for each subject, taken at 6-month intervals, were used for determining the trend of medullation. Thus, 400 hairs from the 16 subjects were examined each 6 months, from the first year through the 9th year, and progressively fewer thereafter.

The medulla count in the 1-year-1-month sample, which was the next group of specimens examined after the 7-month sample, was found to have increased to 46%. This was the highest percentage of medullas found at any period in the 14 years covered by this study. After the 1-year-1-month specimen there is a marked decrease in medullation down to 23% at 2-years-1-month. A gradual climb occurs from 2-years-1-month to 5-years-7-months after which there is

little consistency in trend for the remaining 8 years. In figure 5 the broken line indicates the percentage of hairs which contain medullas for all subjects observed at one-year intervals for 14 years.

A sex comparison of medullation shows that among the limited number of subjects involved in this study, the boys lag slightly behind the girls for the first two years, parallel the girls rather closely between the 2nd and 5th years, and then continue slightly above the girls up to 14 years of age.

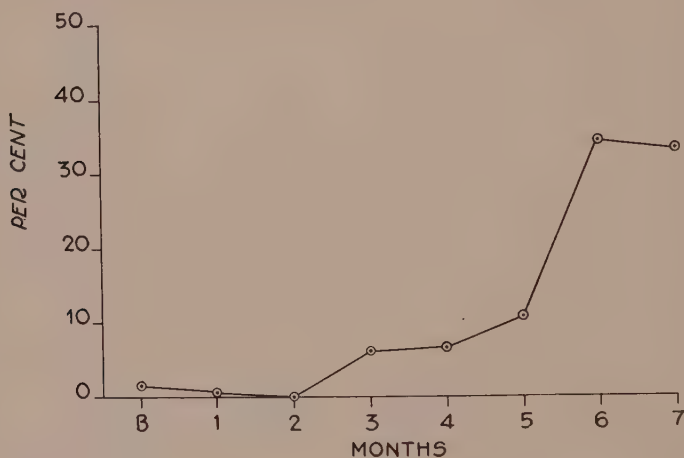


Fig. 2 Graph showing percentage of hairs for all subjects exhibiting medullas during first 7 months.

Figure 3 presents a year by year sex comparison of medullation.

A comparison of the incidence of medullas among the 5 pairs of siblings revealed some similarities. However, more marked similarities were found between some unrelated subjects. A study was first made of each pair of siblings during the period from birth to 7 months, and then for the period from birth through the full extent of the subject's age. It was pointed out above that only two subjects underwent the medulla transition between the second and third month. These were B and F, who are brother and sister. From birth to

three months these subjects followed the same pattern. Between the 3rd and 7th month the curves were at complete variance. From 7 months to 14 years, the type and percentage of medullas in each were somewhat similar with the boy maintaining a slightly higher percentage of medullas.

Brothers C and K underwent the medullary transformation at 5 and 7 months, respectively. Following this transition

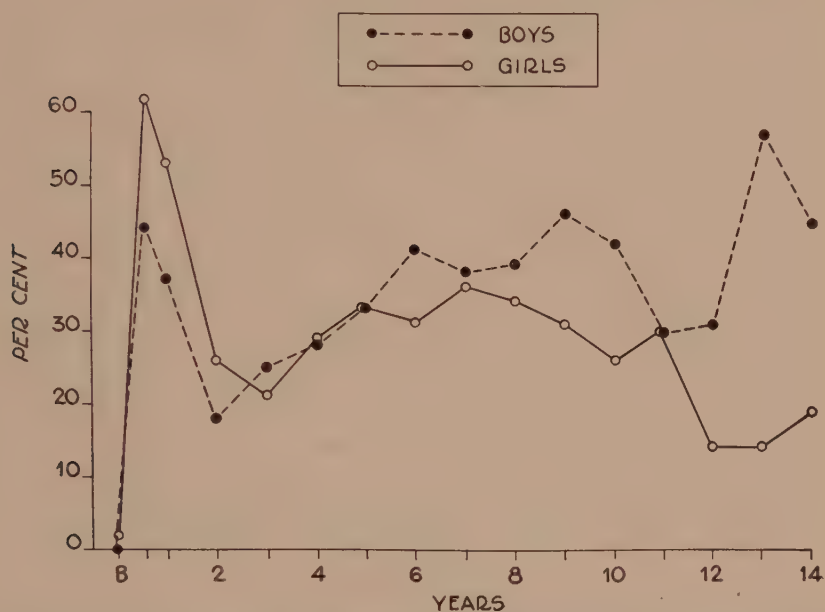


Fig. 3 Graph showing percentage of medullas for each year for boys and girls.

both maintained a somewhat similar trend. Subjects N and E, who are sisters, paralleled each other rather closely, not only during the first 7 months, but throughout the extent of each individual's age.

Neither of the identical twins, L and M, exhibited a medulla for the first 6 months. Subject L suddenly developed a high percentage of medullas in the 7th month, whereas M did not display medullas until 11 months of age. After the first

year, both L and M pursued a rather similar trend in medullas throughout their $9\frac{1}{2}$ years.

Only two subjects other than subject M presented no medullas during the first 7 months of life. These were O and P who are brothers. Both of these subjects exhibited very few medullas among the hairs examined between 7 months and the present time.

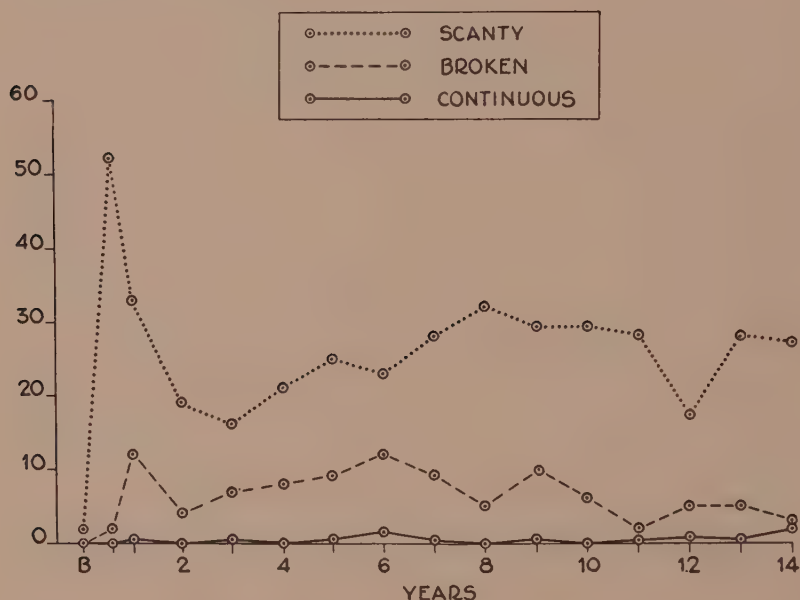


Fig. 4 Graph showing percentage of scanty, broken and continuous medullas for each year for all 16 subjects.

No similarity was found to exist between the cousins C and K and O and P, whereas a rather close similarity was demonstrated between the unrelated subjects H and E, and K and I.

TYPES OF MEDULLAS

The majority of medullas throughout the 14-year span were found to be of the scanty or fragmentary type. Broken medullas did not make their appearance until the third month and then in only one subject. At 5 months, however, they

were found to be prevalent in the samples of a number of contributors. Following 7 months the number of broken medullas remained fairly constant throughout the remaining 13 years with no marked increase or decrease in number. The first continuous medulla made its appearance at 6 months. Following this, continuous medullas were found only occasionally. Again no particular trend among the continuous medullas was evident with age. Figure 4 graphically presents the incidence of each type of medulla, observed at one-year intervals, for all subjects.

A study of medulla types, according to sex shows that the scanty medullas for both boys and girls exhibit rather close parallelism whereas the boys far exceed the girls in the number of both broken and continuous medullas. The total number of broken medullas found after the first year for all the boys was 389 (10.5%), whereas the hair of all the girls contained only 195 (3.5%). Thirty-eight continuous medullas or 1.2% were found among the boys whereas only three unbroken medullas or .05% were observed among the hair of the girls.

MEDULLATION VS. SIZE OF HAIR SHAFT

Since several investigators have demonstrated that there is a direct correlation between medullas and hair shaft diameter (Hausman, '24; Wynkoop, '29), special consideration was also given in this study to hair size as related, not only to the presence of the medulla, but also to the medulla type. Measurements were first made on 25 unselected hairs from each monthly sample from birth through 7 months of age for 8 of the subjects. Thus, the diameters of 1,600 hairs were determined.

A comparison was then made of the incidence of the medullas and the hair shaft size. It was observed that during the first 7 months the hair diameters increased from month to month with only a few exceptions. It was also noted that immediately preceeding or accompanying the medulla transi-

tion in each subject, there was a sharp increase in size of hair shaft diameter.

In subject A, for example, the medulla transition occurred between the 6th and 7th months. This was immediately preceded by a sharp increase in hair size between the 5th and 6th months. Subject B presented two distinct peaks in medulla count: at three months, 47% of the hairs suddenly

TABLE 2

Percentage of hairs containing medullas for each subject for each year

YEAR	SUBJECT															
	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
1 mo.	0	4	0	4	0	0		0	0		0			12	0	0
7 mo.	28	24	72	44	56	36	96	52	56		84	80	0	60	0	0
1*	24	100	40	40	8	100	12	68	12	92	76	40	92	20	0	0
2	12	60	40	64	12	60	4	4	8	12	12	12	28	32	4	0
3	0	64	60	36	0	76	20	0	0	40	8	4	12	20	4	0
4	4	64	68	56	28	60	16	4	12	24	32	8	16	28	4	8
5	12	76	56	28	12	72	32	0	0	88	56	20	32	32	0	0
6	16	68	84	40	12	84	12	0	16	56	32	40	4	40	12	
7	16	36	84	44	16	64	32	20	20	92	28	44	32	16	4	
8	20	20	56	40	48	68	12	4	12	64	60	32	16	72	16	
9	16	48	92	32	12	76	20	16	12	48	60	60	40	12	16	
10	4	32	72	36	12	60	44	0	20	60	36					
11	8	52	64	40	0		16	4	20	68	32					
12	12	20	32	20	0	68	12	12								
13	28		84	12	0	68		4								
14	20	4	52	28												

* The percentage of medullas for the first year is given for 1 month, for 7 months and for 12 months or 1 year in order to show the fluctuation in medulla incidence during the first year. Seanty, broken and continuous medullas are totaled together in expressing the percentage of medullas present in each yearly specimen.

exhibited medullas; the medulla count dropped to 9% and 4% at 4 and 5 months, respectively, and then increased to 59% at 6 months. Each of the peaks in medulla count at 3 and 6 months was accompanied by a corresponding increase in hair shaft diameter, whereas a decrease in hair size was observed at 4 and 5 months, which corresponded with the decrease in medulla count during those months. Similar

diameter increases were observed with the increase of medullation in other subjects. In subject O, where no medullas were found during the first 7 months, it was noted that the hair diameter remained smaller than in any of the other subjects measured.

Table 2 indicates the percentage of hairs containing medullas for each subject for each year; the first year is broken down into 1-month and 7-month intervals because of the

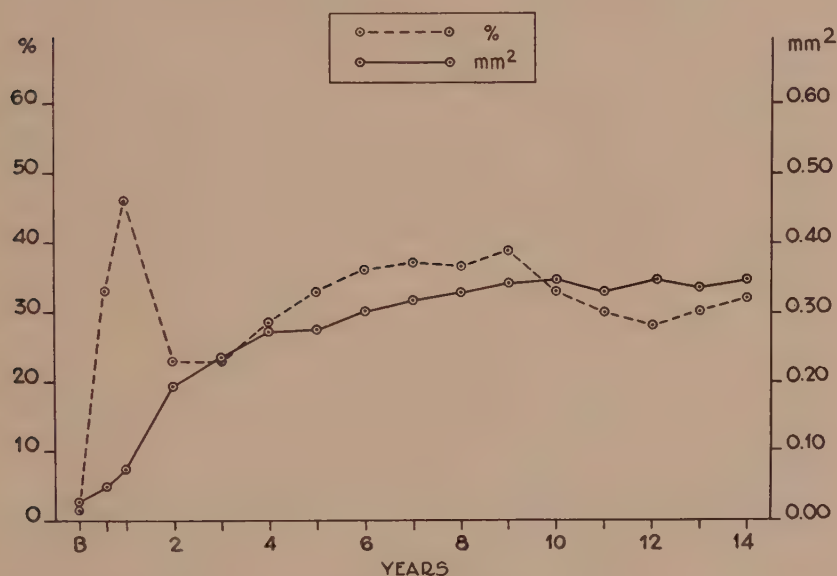


Fig. 5 Graph showing comparison of medulla incidence (in percent) and hair size (total area of 100 hairs in square millimeters).

rapid rise in medulla rate during the first 7 months. A comparison was also made of hair size and medulla incidence for all the subjects over the entire 14-year span (fig. 5). The statistics on medulla count are a composite of all the medullas found in the hair samples of all 16 subjects, with relation to the total number of hairs examined at each age level, expressed in percentage. For example, at one month 0.7% of all the hairs examined for all the subjects contained medullas. No special consideration was given in this com-

parison to medulla types. Scanty, broken and continuous medullas were all included in the total percentage of medullas present. The total area of 100 hairs, expressed in square millimeters, is the figure used at each year in figure 5. It will be noted that the increase in size of the hair during the 14-year period is gradual and for the most part constant. The medulla count, on the other hand, increases greatly during the first 7 months, continues to increase up to one year and then declines rapidly between one and two years. Following the second year, the hair size and incidence of medullas parallel each other rather closely.

Observation, relative to medulla types, failed to show any correlation between the occurrence of scanty, broken and continuous medullas and hair size, with the possible exception of the fact that the very fine hairs of the first two or three months of childhood contained no continuous medullas and very few broken medullas.

DISCUSSION

Several observations can be made as a result of the above findings. First, there appears to be a definite correlation between hair shaft diameter and the presence or absence of a medulla after the second year, i.e., the larger hairs present a higher medulla incidence than do the smaller ones. The sharp rise in medullation from birth to 7 months, the continued rise to one year and the subsequent drop between one and two years, it is suggested, is due more frequently to the type of hair, than to size. As has been pointed out by Danforth ('25), Pinkus ('27), and others, the primary hair or lanugo of the fetus may persist after birth for several months. This hair is described as being devoid of a medulla. The limited examination of the lanugo in this study, at least among the White fetuses, substantiates this theory. Also, the low percentage of medullas (at birth, 1.4%; at one month, 0.7%; and at two months, .02%) can probably be attributed to the persistence of the lanugo at this early age.

The lanugo is followed by secondary hair, vellus, which is the fine hair of post-natal life, and it, in turn, is replaced by the intermediate and terminal types of hair. The increase of medullas, in this study, to 6% at three months, together with the even greater increases in the 4 months immediately following, is probably due to the replacement of the lanugo by a secondary or intermediate type of hair.

The change in hair type from month to month was described by the mother of subject N as it occurred. Two samples were taken from subject N for each of the first 6 months. One of these samples was obtained from the remaining original hair, while the other sample was obtained from the secondary hair which replaced the lanugo on the vertex of the head. At two months the original hair had begun to disappear from the top of the head; at three months the original hair remained only around the sides of the head; by 4 months just a narrow band of primary hair extended from ear to ear; while at 5 months, the original hair was limited to a slight fringe down on the neck. None of the original hair remained at 6 months. Samples of the original hair of subject N taken at 2, 3 and 4 months were found to contain 0%, 4% and 0% medullas, respectively, all of which were extremely fragmentary. The secondary hair, which replaced the lanugo on the vertex of the head in the 5th, 6th and 7th months, was found to contain 84%, 68% and 61% of well-defined medullas.

The rapid transition from the fine, non-medullated, heavily pigmented hair of one month, to the coarser, medullated, sparsely pigmented hair of the next month, can probably be attributed to the rather sudden loss of a large portion of the primary hair and to the subsequent growth of an intermediate type of hair. The fact that the medulla rate drops sharply between the 1-year and the 2-year samples, before maintaining a more or less constant pattern, would tend to indicate that an intermediate type of hair supplants the lanugo before the terminal hair finally becomes dominant. This intermediate type begins to appear between the 3rd

and 7th month, depending upon the individual, and persists to approximately two years of age. It is distinguished from the lanugo by the coarser texture, sparse pigmentation and well-defined medullas. It can be distinguished from the terminal hair, which replaces it, by the latter's smaller percentage of medullas, the increased pigmentation, and the larger diameters. The transition from the vellus or intermediate type to the terminal, appears to be more gradual than the transition from the lanugo to the intermediate. In fact, 6-25% of the vellus hairs persist along with the terminal according to Danforth ('25).

The presence of numerous broken and continuous medullas in the fetal hair of three of the full term Negro fetuses, together with the complete absence of medullas among the White fetuses, suggests that there may be a racial factor involved in medullation in addition to size.

An individual consideration of hair size and medullation showed a rather close correlation in most of the subjects. Subject C, for example, was first among the 16 subjects in hair size and second in medulla count. Subject F was first in medulla count and third in hair size. Subject B was second in average hair diameter and 4th among all the subjects in medulla count. Notable exceptions to the above correlation were subjects A and J. Subject A maintained an average hair diameter greater than all but 4 of the 16 subjects, but at the same time, stood near the bottom of the group in medullation. Subject J was third in medulla count but was in the lower half of the group on the basis of average hair size. The discrepancies in the size — medulla correlations suggest that individual differences are also partly responsible for medullas and medulla types. The hair of subject A contained a very low percentage of medullas throughout the 18 years for which samples are available, yet many of the individual hairs in the monthly specimens of subject A were as large as any observed for the other 15 contributors. Conversely, subject N had relatively small hairs but stood 7th in the medulla count.

The sex differences observed in medullation also appear to be at least partly linked with hair size. In the earlier paper on index and hair size, dealing with the same subjects, it was found that the size of the boys' hair and girls' hair corresponded rather closely during the first 8 years with several of the girls maintaining an average slightly above that of any of the boys. Following the 8th year, however, the size of the boys' hair was greater than that of the girls'. It will be noted that the percentage of medullas present among the girls for the first two years slightly exceeds that for the boys, that during the next 5 years they parallel the boys rather closely, after which the boys maintain a higher medulla incidence than the girls. Of the 625 continuous and broken medullas found among the 16 subjects, 471 or 75% were found in the hair of three subjects, C, B and F. B is a girl whereas C and F are boys. These three subjects also ranked one, two and three in hair size. Continuous medullas were found in only 4 of the 16 subjects. Three of these are boys.

The similarity in incidence of medullas between the siblings is interesting, but since marked similarities were also observed between several of the unrelated subjects, no definite conclusion can be drawn without an examination of a larger number both of siblings and unrelated subjects.

The smallest hairs in which medullas were observed in this study were about 22μ in diameter. This is in fairly close agreement with Hausman ('25), who states that medullas begin to appear in animals when the hair attains a diameter of about 15μ , whereas in man the hair is about twice that diameter. The largest hairs encountered among the 16 subjects were 135μ in diameter.

No correlation was noted between type of medulla and age. This is in agreement with the findings of Wynkoop ('29) and Hausman ('30).

Observations on numerous medullas in this study indicate, as has been suggested by many other investigators, that differences in medullation between the individual subjects

are not great enough for a positive identification of hair as to source. It is believed, however, that a careful study of medullation, where sufficient material is available, may be of great assistance in the individualization of hair. The medullas of a number of the 16 subjects were sufficiently distinctive to make it possible to differentiate between the hair of these individuals on the basis of medulla type.

SUMMARY

More than 20,000 hairs from 16 White children of American parentage were examined for medullation from birth to 14 years of age. These hair specimens were obtained from the vertex of the head and submitted monthly by the parents. Between 50 and 300 hairs were examined from each specimen for the first 7 months. Following this, 25 hairs were observed from each subject's samples at 6-month intervals.

The medullas were listed as absent, scanty, broken or continuous.

Only 38 medullas, all of which were extremely fragmentary or scanty, were found among 5,019 hairs taken from the birth, 1-month and 2-month specimens.

Six percent of the hairs in the 3-month sample exhibited well-defined medullas with the rate increasing to 6.4%, 10.8%, 34% and 33% during the 4th, 5th, 6th and 7th months, respectively. At one year 46% of all the hairs contained medullas. This was followed by a rapid decline to 23% at two years. Subsequently, a gradual rise ensued to 40% at 5 years after which no particular trend was evidenced.

A close correlation was found between hair size and medullation after the second year. This correlation did not exist from birth to two years of age apparently due to intercurrent changes in hair type.

The girls exhibited a slightly higher percentage of medullas from birth to two years, paralleled the boys from 2 to 6 years, and fell well below the boys from 6 to 14 years. This is in close agreement with hair size variations as determined

previously for the same group. The boys were found to exhibit more broken and continuous medullas than the girls.

A close correlation was noted in medulla incidence between the siblings and especially between the identical twins. This correlation was no more striking, however, than that found between several of the unrelated subjects.

No correlation could be found between age and medulla type.

An examination of 15 part and full term fetuses, 9 Negro and 7 White, revealed no medullas among the White fetuses but numerous well-defined medullas in three of the full term Negro fetuses.

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STATISTICS ON MONGOLISM.—The frequency of mongolism among newborn infants is not exactly known . . .

. . . if the frequency of mongolism is assumed to be 1:500, the statistical risk figure for women over 44 years of age will be about 6 per cent, and correspondingly less with a lower frequency in the population. It should be stressed that the risk figures are purely empiric and do not imply any particular theory about the etiology of mongolism, hereditary or environmental.

From a practical point of view the following prognosis may be given. A woman who already has a mongoloid child runs a statistical chance of about 4 per cent of having another mongoloid child. If the parents want another child they should be told that the younger the woman is during the next pregnancy, the better prognosis can be given. Any woman who becomes pregnant after she is 40 runs a statistical chance of about 1 to 6 per cent of having a mongoloid child.—J. A. Böök and S. C. Reed. Empiric risk figures in mongolism. *J. Am. Med. Assn.*, vol. 143, no. 8, June 24, 1950, pp. 730–732.

EXPLANATION OF BLACK SKIN.—After all available data have been examined, the consensus at the present time seems to be that in so far as heat adaptation is concerned the values of a black skin are wholly mythical, and that imputations to the contrary have been very misleading . . .

. . . According to Gloger there is a general correlation of color and humidity or precipitation, so that in a cline or series of closely related forms those occupying areas characterized by high humidity have the darkest pigmentation, while those inhabiting dry or desert areas have the lightest color.

There is ample evidence demonstrating that this correlation of color with the environment is not based on physiological adaptation, but that in all probability concealment is the most cogent factor in producing this result . . .

When viewed from the aspect of skin color as a concealing device, rather than a physiological adaptation for survival in tropical areas, it becomes clearly apparent that possibly we should consider white skins as the anomalous condition, and therefore the phenomenon that constitutes a problem, rather than focus on dark skins as requiring an explanation.—Raymond B. Cowles. The black skin and human protective coloration. *J. Entomol. and Zool.*, vol. 42, no. 2, 1950, pp. 1–4.

THE CONSISTENCY OF ANTHROPOMETRIC MEASUREMENTS¹

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ONE FIGURE

It is the purpose of this paper to examine a large number of anthropometric measurements in order to determine those factors which contribute to consistency. Such a study would aid the research worker to estimate the consistency of any measurement he may choose to use, to interpret the data already in the literature, and to establish a basis for selecting measurements for use in future research.

Consistency, the differences in repeated measurements when the subject and technique remain constant, has been investigated by Dahlberg ('26), Davenport, Steggerda and Drager ('34), Knott ('41) and others. These studies indicate that consistency increases as: the number of technicians decreases, the amount of subcutaneous tissue decreases, the experience of the technician increases, and as the landmarks are more clearly defined. Absolute size of the measurements usually has not entered explicitly into their discussion, but their data indicate that absolute size of the differences between repeated measurements increases as the means upon which they are based increase.

Most of these studies have been based on comparatively few measurements and little attempt has been made to determine the factors which influence the consistency of a measurement. In this study, a classification is set up whereby those

¹ This paper is part of a thesis submitted to the faculty of the Department of Anthropology, University of Chicago, in partial fulfillment of the requirements for the Master's Degree.

factors common to measurements of equal consistency can be isolated.

MATERIAL AND METHODS

The data of this study were obtained during the Army Quartermaster Corps' anthropometric survey of male sepa-
ratees. Six teams were trained, and the work so divided that any one technician took only one-fourth of the total number of measurements. In all, there were 8 series of measurements taken by 6 teams on 5 subjects. One subject was measured by three teams, but no subject was measured by all. The material covers 62 measurements each taken at least 10 times by one team on one subject; most were taken 30 times with a maximum of 49. Every team did not take the full compliment of measurements. (For a description of technique, see Randall and Baer, '47.)

The mean, standard deviation, and coefficient of variation were determined for each measurement according to team and subject. In data such as these, the mean is an indicator of the technique used, while the standard deviation and coefficient of variation are measures of the consistency with which that technique was employed. Although all teams received the same instruction, they cannot be expected to be equally consistent. Therefore, in order to study the consistency of measurements, rather than the consistency of a particular team, the means, standard deviations and coefficients of variation obtained by all the teams were averaged for each measurement, due weight being given to the number of times each team took the measurement. Table 1 gives the average of means (\bar{M}), the average of standard deviations (\bar{S}) and the average of coefficients of variation (\bar{V}) as well as the number of series of measurements available.

In general, the standard deviation increases as the mean increases (fig. 1). This is to be expected as it merely signifies that, other factors being equal, long measurements vary absolutely more than short ones. That other factors are operating is shown by the range of the standard deviation for any given

sized mean. In order to analyze these factors, the mean was divided into 100 mm classes, and the measurements grouped according to their position within the standard deviation range of their mean class. The process was carried out on the scatter diagram (fig. 1), where boundaries between consistency groups

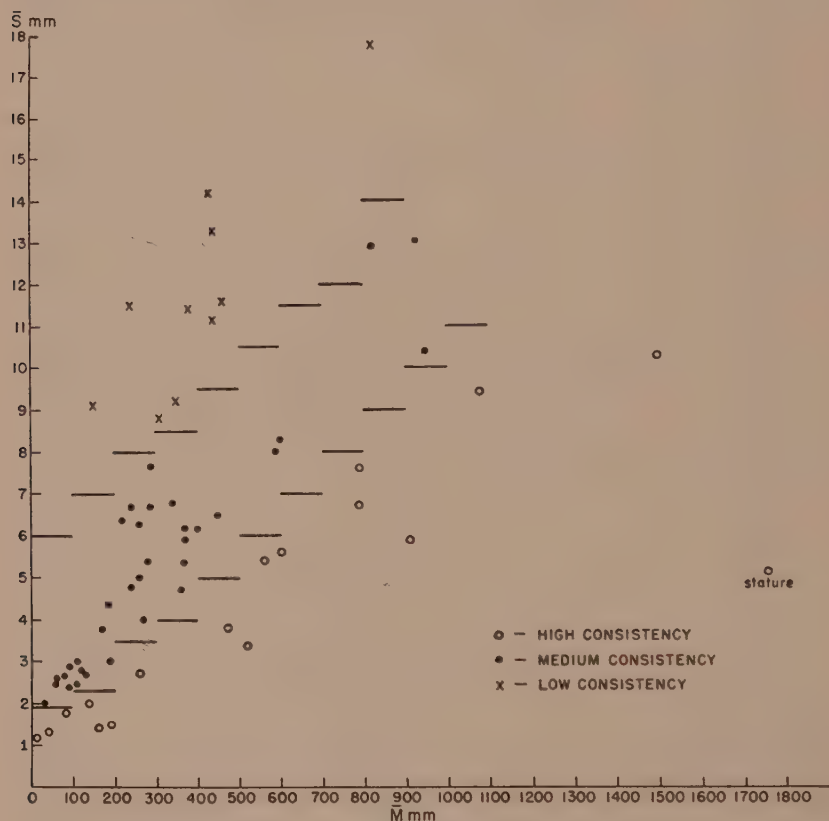


Fig. 1 Standard deviation plotted against size of mean. Horizontal lines indicate divisions between consistency groups.

were placed where there was a break in the vertical distribution. In the 200–300 mm class, for example, there is a central clustering of dots with a break at either end separating the dot at 2.7 and the one at 11.5; the division was made at these breaks. The same procedure was followed in the subsequent

classes with the proviso that with increase in the mean, there would be an increase in the standard deviation due to size. The boundaries between groups should follow, therefore, a slanting line.

A three-fold classification emerged as shown in table 1 and indicated in figure 1. That group with the smallest standard deviation for any given mean is called high consistency; that with the largest standard deviation is called low consistency and the middle group is called medium consistency. Such a procedure is, in a sense, arbitrary. That it does have validity is shown by the fact that the coefficient of variation definitely increases from the high to the low consistency groups. The coefficient of variation does not establish clear cut boundaries because it is not entirely independent of mean size, but over-emphasizes the variability of small measurements. More importantly, this classification permits the formulation of general statements as discussed later.

Stature has not been placed in any group. It is the longest measurement in the study and has a much smaller standard deviation for its size than would be expected from a consideration of the others. It has, therefore, been kept separate.

DISCUSSION

In the high consistency category, either both landmarks are determined by the measurement, or the one which must be found is an easily located bony eminence. An example of the first would be bizygomatic breadth where zygion is actually that point which the caliper touches when the measurement is taken. The second group uses cervicale, cristale, acromiale, or glabella. These must be found before the instrument is applied, but are easily located with precision. (For a classification of measurement, see table 2.)

Head circumference is the only tape measurement in the high consistency group. It is not only taken in a position where there is a minimum of subcutaneous tissue, but also was routinely taken three times, and the maximum value accepted.

Such a checking mechanism is known to increase consistency (Lincoln, '30).

The medium consistency measurements may be subdivided into three groups. In the first, both landmarks must be located prior to taking the measurement. In bigonial diameter, the gonion must be located and then the instrument applied; this is basically a different process and more open to differences in location than that involved in the location of zygion. The cir-

TABLE 2

Classification of measurements according to factors determining consistency

HIGH CONSISTENCY MEASUREMENTS	
A.	Both landmarks determined by the measurement: Inseam, buttock-knee, patella ht., forearm-hand lgt., foot lgt., head br., bizygomatic br., hand br., nose br., nasal root br.
B.	One landmark located independent of the measurement: Cervicale ht., outseam, sitting ht., and head circum., head lgt., arm lgt.
MEDIUM CONSISTENCY MEASUREMENTS	
A.	Both landmarks located independent of the measurement: Hip circum., sleeve lgt., crotch thigh circum., lower thigh circum., shoulder-elbow lgt., neck circum., lower upper arm circum., upper arm lgt., bi-iliac br., upper forearm circum., ankle circum., ball foot circum., wrist circum., head ht., face lgt., min. frontal dia., bigonial dia., outer canthus-otobasion superior, nose lgt., interocular br.
B.	Measurements of the chest: Chest circum., trunk ht., chest br., trunk depth, chest depth.
C.	Others: Bideloid br., hip br., foot br., heel br., hand lgt., instep lgt., middle upper arm circum., calf circum.
LOW CONSISTENCY MEASUREMENTS	
A.	Anthropometer: Bi-elbow br., (lower leg lgt.).
B.	Tape: 1. Ill-defined landmarks: Waist circum., middle thigh circum., arm scye, (upper leg circum.), axillary arm circum., middle forearm circum., shoulder lgt. 2. Tape position determined by other measurements: Total crotch lgt., cross back width.

cumferences are taken either just above or below a joint where the bony eminences determine the position of the tape.

The second subdivision consists of chest measurements. Here the technician has no objective method of determining whether or not the lungs are inflated the same amount on any two occasions. However, the amount of movement is not great enough to place these measurements in the low consistency category.

The third subdivision consists of measurements having a resemblance to the high consistency group, but which possess some feature leading to greater inconsistency. Bideloid and hip breadth are measurements which determine their own landmarks. However, in both cases, the technician is directed to merely graze the skin with his anthropometer at two points which cannot be seen simultaneously. It is this aspect which places a qualification upon the high consistency measurement, for in that case, the measurements are of such a nature that the technician can easily determine whether or not his instrument is in the proper position when the reading is taken.

Calf circumference is like head circumference in that it was repeated three times, the maximum value recorded. It is unlike the measurements of the low consistency group as the position of the tape was not defined in terms of the skeleton. The factor for increased consistency cancelled that for decreased, placing calf circumference in the medium consistency group.

Foot breadth, heel breadth, instep length, hand length, and middle upper arm circumference have an indefiniteness in the location of either the landmarks or the position of the tape. For instep length, the technician is directed to measure from the most posterior point on the heel to the center of the medial projection of the first metatarsal-phalangeal joint. This projection is an area in which the technician must estimate the center. The consistency is no better than the estimate, but the doubtful area is small, and the differences are less than for similar indefinite measurements in the low consistency group. The same reasoning holds true for middle upper arm circumference, where, because the muscle borders are nearly parallel

when the arm is extended, greater consistency is expected than in similar positions on either the forearm or thigh.

In the low consistency group there are only two anthropometer measurements, lower leg length and bi-elbow breadth. According to the criteria given above, lower leg length should be a high consistency measurement. The very large standard deviation is probably due to the inability of the Army technicians to locate tibiale accurately. The same reasoning would indicate that upper leg circumference should be a medium consistency measurement. Bi-elbow breadth (the elbow breadth of Randall and Baer ['47], is not the same as elbow breadth of growth students) not only measures a very mobile structure, but also the technician must determine two landmarks which cannot be seen simultaneously.

The tape measurements are defined either in terms of other measurements which are of low consistency, or the position of the tape is not determined by easily located bony points. In taking middle forearm circumference, the technician must estimate that point which is halfway between two joints. A very slight difference in estimation will produce a considerable difference in the results. The landmarks for total crotch length are those two points, anterior and posterior, where the tape, in taking waist circumference, crosses the mid-line. Any difference in total crotch length is actually the summation of differences in two measurements instead of one.

Stature is by far the most consistent of all the measurements. The ease with which it is taken is the most probable explanation. The only precautions which the technician need take are proper position of the subject and of the instrument. With the exception of sitting height, all other measurements involve these considerations plus others discussed above.

In this study, numerous technicians were used. Previous studies indicate that consistency decreases as the number of technicians increases (Knott, '41). Therefore the values given in table 1, actually represent a maximum amount of inconsistency to be expected. It is very unlikely that any study in the near future will make use of approximately 60 technicians

for each measurement. When the results of this study are compared with those obtained by Davenport ('34) the same pattern of consistency is found. Although a detailed classification was not attempted in that paper, the same factors are indicated.

SUMMARY AND CONCLUSIONS

This study is based on 62 measurements taken by 6 teams on 5 subjects. The average of the standard deviations and coefficients of variation for each measurement were used as measures of consistency, the differences in repeated measurements when the subject and technique remain constant. The measurements were divided into three consistency groups, high, medium and low, and the factors which brought about this division were analyzed.

It was shown that as the size of the mean increases, the deviations about that mean can be expected to increase. The size of these deviations will be smallest when the position of the subject and instrument are the only factors involved. The deviations increase as the technician must pay more attention to the landmarks. The differences between those measurements in which both landmarks are determined by the instrument in the process of taking the measurement, and those in which only one easily located landmark is used, is negligible. The consistency decreases when the landmarks are independent of the measurement, when there is no objective method of placing the structure to be measured in a standard position, or when the technician must estimate the position of his instrument either because he cannot see both landmarks simultaneously or because the landmarks are not easily located in terms of body markings. The consistency further decreases when a very mobile structure is measured, when the position of the instrument is very indefinite, or when the landmarks are defined in terms of other measurements.

When only one technician is used, the consistency of all groups will increase, and the consistency should more closely approximate that of the Davenport study.

No attempt has been made to define a good measurement. Its quality is determined by many things; primarily by the use which is made of it. A low consistency measurement would be good if it were the only one which would give data for the solution of any given problem. However, the interpretation of such data should be colored by the expected consistency of the measurements used.

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COMPARATIVE SPLANCHNOLOGY.—The literature has been reviewed relating to the question of presence or absence of valvulae conniventes (plicae circulares) in the small intestine of the great apes, with the conclusion that they may be regarded as constant in *Gorilla*; reasonably so in *Pongo*, but usually absent in *Anthropopithecus*.

Material examined personally shows the presence of valvulae conniventes in *Gorilla*, their absence in some orangs examined and their presence in one out of four chimpanzees.

The arrangement of the colon, with special reference to its left part, has been considered in young and adult apes; and the conclusion drawn that this intestine is larger relatively at all ages than in man, and that in the adult the large erect loop on the distal colon of juveniles persists and in fact increases in size, forming a recurrent limb parallel to the descending colon, succeeded by a caudally directed or paravertebral limb continuous with the rectum.

The most advanced arrangement occurs in adult chimpanzees and orangs, the gorilla retaining a rather infantile arrangement referred to by Duckworth as the omega-loop.—W. C. Osman Hill. Some points in the enteric anatomy of the great apes. Proc. Zool. Soc. London, vol. 119, pt. 1, 1949, pp. 19-32.

ORIGINS OF BLOOD GROUPS ABO, AND THE EUROPEAN MONGOLOID PROBLEM

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FIVE FIGURES

The first purpose of this paper is to present the evidence for a single racial origin of most, if not all, of the blood group B genes in the world, together with the evidence for a poly-genetic source of blood group gene A. The second purpose is to present the evidence against a Mongoloid source of most of gene B in Europe.

In order to make the following rather cursory presentation of the statistical evidence for the major theses of this paper intelligible to the reader, it is necessary to state the point of view from which it is written. At a time in human evolution, which may well have been the late Pliocene, the readily accessible and habitable portions of the world are assumed to have been populated by various homonid forms, of which the South African ape-men may have been retarded survivors. Somewhere, probably in Asia, the ancestral homonid became dominant, and spread gradually over the territories occupied by his cousins, whom he ultimately displaced. At this stage in human history, through operation of the factors of mutation, selection, and genetic drift, largely in geographical isolation, racial differentiation occurred just as it has for other mammalian species. At the then existing stage of cultural evolution, movement was presumably slow, and little can be said regarding the importance or extent of the earlier hybridization.

It is likely that the ancestral homonid possessed blood groups A, B, and O, as Boyd ('40) has suggested, since A and B, or substances indistinguishable from them, have been found in the anthropoid apes. In the more peripheral areas to which man migrated, conditions may often have been unfavorable. Hence small populations may have been widely scattered over large territories. Even so, if many isolated groups had survived, and if later mixture of the territorial population had taken place, the most likely outcome in respect to blood group ratios, barring mutation or selection, would have been little change. Under unfavorable territorial conditions, however, most local populations may have remained small or have perished, and the larger part of the surviving population may have been descended from a few groups which had either become best adapted genetically or culturally, or had encountered a less difficult local environment. Under such conditions the most likely effect, with respect to the total territorial population, would be greater or less loss of the least frequent blood group genes, B, and perhaps A. In the meantime, at the center, or in territories in which larger numbers of scattered bands survived, the gene loss was probably not so great, and gene A or B, aided, perhaps, by mutation, may have become concentrated. The evidence, that in most anciently inhabited peripheral regions of the world genes A and B were largely or completely lost, is given below.

In respect to morphological features, since, by hypothesis, the central regions were more densely populated, the probability of occurrence of favorable mutations was there enhanced, and change in phenotype progressed more rapidly.

We may go one step further in these speculations. Hybridization was facilitated by advance and retreat of the glaciers, and, therefore, Europe and Asia Minor were possibly major arenas of early racial mixture. And we may also surmise, again with supporting evidence from blood group distribution, that during the protracted interglacial periods in Europe, the autochthonous population was gradually infiltrated by stragglers from the South and East. The most likely outcome would

be retention of the selectively favorable phenotypical traits introduced from without, with consequent gradual change in the phenotype toward the advanced types of the infiltrators. In contrast, the introduced blood group genes, which probably have no selective value, would tend to be lost, so that the frequencies of the earlier indigenous population would tend to be retained. Ultimately, therefore, the majority of the genes would be those derived from the outsiders, excepting the blood group genes. If, perchance, the infiltrators possessed many more M than A genes, perhaps M, rather than A, more clearly indicates the relative importance of the two races in the hybrid, and in this connection, Rh is probably important also. An example will illustrate the reason for this inference. Ireland is low in gene A, yet gene M approximates western European levels. If the indigenous population was low in M and the infiltrators very high, perhaps the m/n ratio more nearly reflects the relative proportions of the two components in the hybrid than does the frequency of gene A.

The terminology employed in the following pages may be misleading unless certain words are defined. "Negroid" refers to populations which have hybridized, usually with Whites. Proto-Negritoid refers to a hypothetical ancestral type, which is regarded as the major component in the African Negrillos and the peninsular and insular Negritos. On the other hand, the Chinese and Japanese, as well as the Tungus tribes and the Buriats, are Mongoloid, but, unless otherwise stated, the term Mongoloid here refers to peoples in whom phenotypical evidence of a Caucasoid component is lacking or minimal. In this sense, the Japanese and many Chinese and Koreans are excluded.

I. THE MONOGENETIC ORIGIN OF GENE B

In this section the evidence for a single racial origin of gene B will be presented, together with briefly stated speculation regarding the race which possessed that gene. The evidence consists chiefly of rather remarkable correlations be-

tween the frequencies of genes A and B, which are found, more or less clearly, over much of the world.

Mongoloid territory. The literature contained two obvious hints which led the author to plot the diagram of figure 1. The first was Candela's ('42) observation that the frequencies, both p and q, were much lower in the Tungus Mongoloid type than in the Buriat or Kalmuck. The second was the descrip-

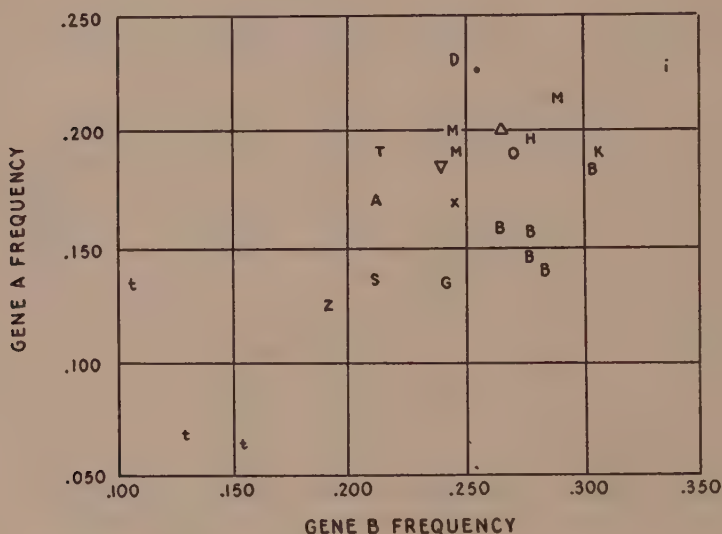


Fig. 1 Ordinates, frequency of gene A; Abscissae, frequency of gene B among Mongoloids. A, Altai, mixed; B, Buriat; D, Dahur; G, Goldi; H, Hazara; I, Ichemzes (Kola Peninsula); K, Kalmuck; M, Manchu; O, Orochi; S, Sungari-Goldi; T, Telengit; t, Tungus; X, Shansi Aborigines; Z, Tubalar; ●, Tungus in Manchuria; Δ, Kypehak; ∇, Mongols. The Giliak are omitted because of known mixture with Ainu. The coefficient of correlation is 0.624 ± 0.138 , which is 4.5 times its probable error.

tion, following Bartucz, given by Coon ('39, p. 230) of the skulls from Hunnish (Tungus type) and Avar (Buriat type) cemeteries. The Hunnish type was plainly the more "primitive," that is, more "Upper Paleolithic." And this type was probably lower in genes A and B.

Since the author is not able to judge adequately which of those Mongoloid tribes listed in Boyd's ('39) tables are less

and which are more Mongoloid, the individual points in figure 1 are indicated by letters, and the caption gives the population sampled in each case. Thus, the reader can check the data. The coefficient of correlation, r is 0.624 ± 0.138 . This may be taken as significant.

In judging the merits of the correlation, it may be noted that two of the Tungus groups, the Buriats, Kalmucks, Goldi, Sungari-Goldi, and Tubalar are fairly close to a line giving a ratio, p/q , of $\frac{1}{2}$. Probably none of these tribes has fully escaped hybridization, either with the Bronze Age Nordics, who extended as far as the Altai Mountains, or with Turkish or Tatar peoples of Mediterranean race (Coon, '39), both of whom, to judge from their descendents, must have possessed fairly high levels of gene A, and usually less of gene B. The Manchu are hardly "pure" Mongoloids, and they, like many of the other tribes, have more of gene A than the Buriats.

Other peoples in Asia, notably the Japanese, some Koreans, and, in particular, the Chinese of Hunan, are high in gene A. These peoples are evidently not "pure" Mongoloid.

A tentative conclusion may be drawn from the foregoing facts. The Mongoloid peoples are analogous to the Western Europeans, that is, they are a hybrid between an autochthonous form, strongest in the Tungus, which belonged almost entirely to blood group O, and an invading people, in whom the frequency q was high, circa 65–70%, and the frequency p was lower, circa 25–30%.

Africa. Lest the thread by which the foregoing hypothesis is suspended seem too tenuous, we may proceed to Africa, and a consideration of figure 2. Here, unlike the Asiatic region, we do not have to select actually or putatively relatively pure "races." With unimportant exceptions, to be explained, all the data in Boyd's tables from South, West, and Equatorial Africa are plotted, and three series from America are added. Although the latter have hybridized with whites, they are certainly not less Negro than some East African tribes. The omissions from the data in Boyd's tables are: Three less reliable Pygmy series, although two of these correlate well;

two most unreliable series; one mixed Pygmy-Negro series; and all the Bushmen, who, serologically, are a different race. Another series, not included, was from Buren, Transvaal. It is precisely repeated, with the reference to Pijper, under Holland, S. Africa; it is quite obviously a white group and is so listed by Wiener ('43). A series on the Alur, who are known

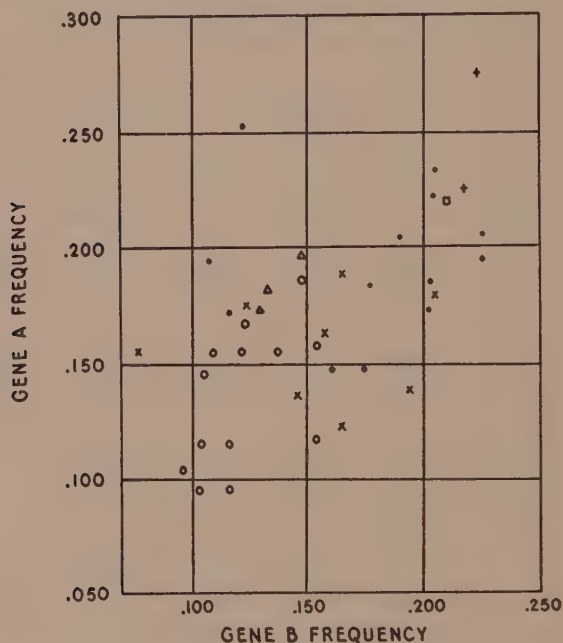


Fig. 2 Africa, as in figure 1. ● = Equatorial Africa; O = South Africa; X = West Africa; + = Pygmies; □ = Hottentots, △ = American Negroes. Coefficient of correlation: 0.52 ± 0.11 . The black circle at upper left is the Alur, the point below this, to left, is the Balese, and the X, with low q value, is a Kru speaking tribe. The Tebu of Tibesti were omitted because they often have non-Negroid hair and features.

to have moved from the North into their present territory, was nevertheless included, though they must contain much "Hamite." One small "Kaffir" sample is badly out of line; it could be a hybrid, and it is excluded, together with the Tebu of Tibesti, who contain a large White element (Dixon, '23). For the remaining 39 series, $r = 0.52 \pm 0.11$. Since the

coefficient is 4.7 times its probable error, it is significant. As in Mongoloid territory, many of the population samples in figure 2 must contain White elements, and this may make the correlation poorer. Thus, the desirability of basing such studies on those populations which exhibit an apparent minimum of recent hybridization is evident. It is, therefore, obviously desirable to secure adequate physical data on a sufficient number of scattered populations, together with the blood group ratios.

In comparing figure 2 with figure 1, it will be noted that the ratio, p/q , is not the same. In Africa the frequency of gene A is slightly higher than that of gene B on the average. The chief reason is that the proto-Negritoid possessed gene A, but little or no B. It will be necessary at this point to present the evidence for this statement.

The level of gene A is fairly high among the Negritos of the Philippines, among many Papuans, and among the culturally primitive tribes of India who show the most Negritoid features (Paniyan, Maler, Kanikkar; see MacFarlane and Sarkar, '41). Some of the gene in Australia was presumably derived from the Negritoid element. The African Negrillo has a high frequency, and the levels in Hottentot and Bushman are not very low (Boyd, '39). The Negro will be considered later. The Negrillo, for example, has almost as high a level of gene A as the Egyptian. Unless the gene was present in the proto-Negritoid, it is difficult to imagine what its source may have been.

Gene B is low in the Philippine Negrito, in the Papuan, and in the Bushman; it is absent from Australia, except in the north (Birdsell and Boyd, '40). As shown later, it must have been low in the proto-Negritoid of India. A rough estimate, therefore, suggests that in the ancestral Negritoid (proto-Negritoid) the approximate frequencies were: $p = .200$ or more; $q = 0$; $r = .800$ or less.

It is a remarkable fact, which is quite as important to the argument as the correlation, that as a rule the Hamites and the Negroids of the Sahara region, as well as the Egyptians, often have gene B levels which are as high as, or in a few instances even higher than, the frequency in the Negrillo (Boyd,

'39). It is obviously impossible to attribute the high frequency in Egypt to hybridization with the Negrillo, and still less possible to attribute it to the Negro, whose gene B frequency is lower than that of the Egyptian.

Of course, the geographical proximity of Negrillo and Egyptian, together with their equal gene B frequencies, may be fortuitous; but when we observe a similar coincidence in gene frequencies among Mongoloid and non-Mongoloid populations in Asia, the argument for a similar racial element in hybrid populations is strengthened.

The Negro is consistently lower *both* in B and A than the Negrillo, yet the ratio, p/q , is very much the same.

How are these facts to be explained? If we take two parts of the hypothetical proto-Negritoid and add about one part, or a little less, of the same hypothetical A-B bearer, who entered Mongoloid territory, we obtain the average gene frequencies of the Negrillo. If we combine about a third of this same Asiatic A-B bearer with the classical Mediterranean, we come very close to the gene frequency of the Egyptian. If we add some of this same "race" to the Negro, we get the gene ratios of many Saharan tribes; and if we add it, plus a little Negro, to the Bushman, we get the frequency of the Hottentot. If, on the other hand, some Negroid peoples in Ethiopia and elsewhere are rather high in gene A and not high in gene B, we at least have evidence from Europe (as will be shown later) that a B-deficient Mediterranean constitutes part of the Egyptian; and the same Mediterranean could well have gone southward.

The Negro yet needs to be explained. It is here proposed that Africa, like Northwestern Europe and Mongoloid territory, contained its own autochthonous race, before the entrance of the mixed or unmixed proto-Negritoid. Where the B-deficient proto-Negritoid hybridized with the autochthonous Boskopoid, we find Bushman. When the Negrillo hybridized with another autochthonous African, which lacked both A and B, we find Negroes. It is very difficult otherwise to explain the blood group distributions. The Negrillo is not uniform (Val-

lois, '40). It would be interesting to know whether those tribes reported to carry less of gene B are closer to a hypothetical proto-Negritoid in physical features.

India and Indonesia. India is, of course, racially much mixed. The indigenous populations were probably proto-Negritoids in the south, where gene B is less frequent today, and proto-Veddoids in the more open north. To these elements have possibly been added a European type of "Upper Paleolithic," Indo-Afghans, and Nordics (Guha, B.S., quoted from Hooton, '46), and possibly also a gene-A bearer who may have introduced the Austroasiatic languages farther east. Perhaps earliest among the invaders was the A-B bearer.

Presumably because of the great extent of hybridization, the correlation between the frequencies of gene A and B is not statistically significant in India. Yet if all the series from India in Boyd's tables which have an A frequency in excess of 0.230 are omitted — these being attributable to excess Negritoid or excess Indo-Nordic and Irano-Afghan — a distinct trend, similar to that in Mongoloid territory, is observable. And in Indonesia likewise, if Negritos and some of the more "primitive" peoples are excluded, a similar trend is seen. But in Indonesia, which lies farther from the center, genetic drift may well account for the greater fluctuations in the ratios. By a process of elimination, assuming all the components are known, it appears that the element in India which possessed mainly blood group O genes was the Veddoid. In Indonesia, many of the more primitive peoples are low both in A and B; so a diluent may also have been present there, or was carried in, in the genes of the invaders. In Indonesia, also, there is a strong indication that the bearer of gene B also possessed gene A, the ratio p/q being probably a little less than one-half.

Who was the hypothetical carrier of gene B? It may not be impossible to determine which race possessed gene B, and introduced the gene into the rest of the world. One hint is obtained from the data on culturally primitive tribes of India, published by MacFarlane and Sarkar ('41). Both the blood

groups and certain physical characters of these tribes are given by the authors. In figure 3A, q is plotted against the nasal index of 11 tribes, and in B of the figure q is plotted against a number which combines nasal index and stature. In deriving this product both nasal index and stature were expressed for each tribe in terms of percentage on a scale which gave the approximate human range in each character. Broad noses and low stature were given the lower percentages, these two percentages were then multiplied for each tribe, and the products were plotted against B frequency. It will be observed that there appears to be a good correlation in both parts of the figure, only the Chenchu being seriously out of line. No coefficient was calculated, because of the small number of cases. The wider the nose and the shorter the stature, the lower the frequency of gene B. We may infer two things from this. The proto-Negritoid (and Veddoïd?) possessed few or no B genes; the race which contributed B was of taller stature and had a narrower nose than the proto-Negritoid. Also indicative is the fact that the mainly leptorrhine peoples of the Northwest of India (Dixon, '23) possess many B genes; and the same gene is frequent in southern Iraq and in the Syrian and Arabian Deserts, but is probably less frequent in the Hadhramaut where the Veddoïd element is strong (Coon, '39).

Reasons will be given later for believing the classical Mediterranean was not a bearer of gene B. Another Mediterranean racial element in these regions is the darker-skinned, black-haired, Mediterranean, who shows none of the usual incipient blondism of the ordinary Mediterranean type (Coon, '39). It is suggested that this type, which has today nowhere escaped hybridization, might have combined with the proto-Negritoid to yield the Negrillo, selection over a long period having eliminated clear evidence of its presence in the hybrid. It is also a type which, combined with the very different proto-Mongoloid, could have produced the Mongoloid. Again, careful correlation of the frequency of the genes and of physical characteristics among the appropriate populations should give

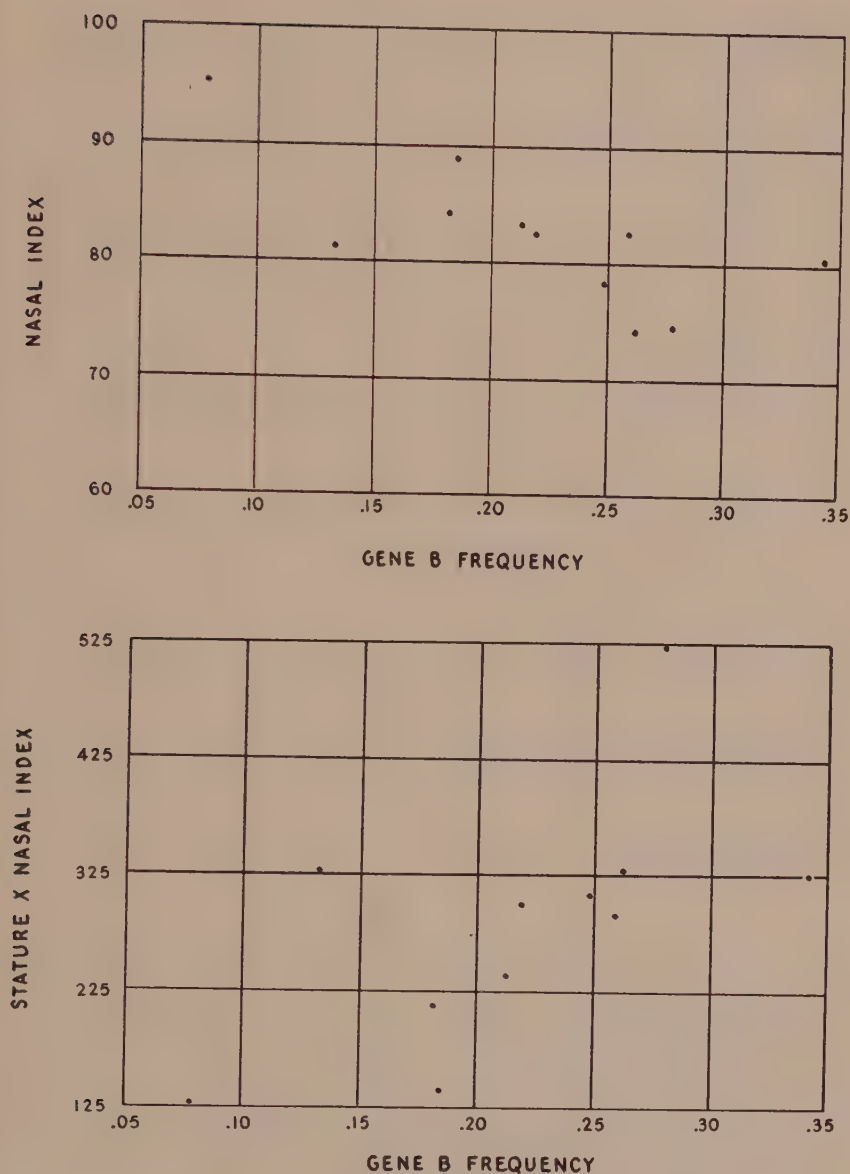


Fig. 3 Above, nasal index plotted against frequency of gene B; below, stature combined with nasal index, plotted against q (see text). The negative correlation between q and N.L. is, at least, strongly suggestive, $P = 0.01$. In part B the approximate $P = 0.04$.

a definite answer to this question.¹ It may be suggested here that this race is a subrace of *H. sapiens*, proper, as defined by Coon; and one which differs from the latter in a number of genes, including those determining the blood groups. It is relevant at this point to suggest that the common element which assimilates all surviving populations into the species *H. sapiens*, in contrast to the flat-brained Paleolithic races, is the Mediterranean, which includes its A-B bearing subtype. It is suggested, further, that no population today lacks a substantial sapiens element, as defined by Coon, excepting the South African Bushman, and, perhaps, the untested Andaman islanders. This view implies world-wide migration and mixture; yet, within its southern habitat the proto-Negritoid has obviously ranged nearly as far.

This suggestion of a common racial element, present as a minority factor wherever gene B is found, is analogous to the postulation, by Hirschfeld and Hirschfeld (quoted by Wiener, '43) of an Asio-African race.

It may also be suggested that the most probable area of characterization of the A-B bearing subrace was Arabia; that it contributed early to the western Negritoid, either before or after the latter reached Africa; and that it was forced to migrate, earlier than other "primary" races, by desiccation in Arabia, either during the Mesolithic, or during a previous interglacial period.

II. ORIGINS OF GENE B IN EUROPE

In the foregoing sections of this paper, evidence for a single racial origin of gene B has been presented; and reasons have been given for believing that this gene was not present in the proto-Mongoloid, but was introduced into Mongoloid territory

¹ If this view is correct, the recent findings of Sarkar ('49) are of extraordinary interest. The Birjias, Kharwars, and Kisans of India, on the basis of small samples, however, appear to have gene B frequencies, which are among the highest in the world. A search for common physical similarities in these peoples, the Bhils (MacFarlane and Sarkar, '41), the Kalmucks and Buriats, and, perhaps, the Negrillos, etc., might define the postulated A-B bearer, and make possible its tentative identification among known skeletal remains.

by invaders of a different racial type. Because of the effects of genetic drift, selection, and hybridization, the correlations upon which the arguments are mainly based are, perhaps, less clear than they otherwise would be, and the conclusions, pending adduction of much supporting evidence, are recognized as speculative. It is otherwise with respect to the European area. Here the weight of the evidence against a mainly Mongoloid origin of gene B is impressive. This evidence will now be presented.

(a) *The observed frequencies of gene B imply far too great a Mongoloid element in certain European areas.* Although this line of evidence is presented first, it is probably least conclusive. We do not, in fact, know to what extent the appearance of the Mongoloid phenotype is dependent upon physical characters determined by the presence of gene complexes, which may have been broken up by hybridization.

We shall first need to consider the frequency of gene B among the Mongoloid peoples of Asia. For this purpose, an unweighted average was obtained for all the largely Mongoloid populations listed in Boyd's ('39) tables. This closely approximates 0.240. However, as Candela ('42) points out, there appears to be much variation in B frequency in different Mongoloid peoples. The data on the Tungus type, to which the Huns belonged, are scanty and unsatisfactory, but they do suggest a B frequency far below 0.240. On the other hand the Buriat Mongols, similar in cranial form to the Avars, have a B frequency averaging 0.285. In view of the evidence from Bronze Age remains that a blond, apparently Nordic, racial type extended eastward as far as the Altai Mountains (Coon, '39, pp. 169-170) it is improbable that any Central Asiatic Mongoloid group has fully escaped hybridization. This may have decreased the frequency of gene B in the Buriats. We shall ignore the fact that the Bronze Age antedated the historic Mongol invasions, and also disregard the fact that the Mongol armies were only partly Mongoloid. We shall assume that the invaders were mainly of the round-headed or Buriat type, and that in them the frequency of gene B was greater than 0.300,

e.g., 0.320. Since only two satisfactory Mongoloid population samples in Boyd's tables have a frequency in excess of 0.300, we are hardly justified in assuming a greater frequency than 0.320. We shall make the further assumption, also with Candela, that before the Mongol invasions gene B frequency in Europe was very low, or even zero.

We may now turn to the European populations, relying chiefly upon Haldane's ('40) recapitulation of the tables. In Europe, gene B frequencies reach or exceed 0.160 in Eastern, Central, and Northern Russia, in Esthonia, Latvia, and much of Poland. The excellent data from Finland reveal that in many districts the frequency exceeds 0.160. In Hungary, where Bartucz (quoted by Coon, '39) found Mongoloid traits in 5% of the population, gene B frequency is not quite 0.140, although it may be slightly higher among the Magyars. In part of Finland, where the frequency equals that of Hungary, when the Swedish speakers are excluded, the Mongoloid eye was found in six individuals in a thousand (Coon, '39).

According to our assumptions, a B frequency of 0.160 would imply that just 50% of the genetically determined physical traits in the population are of Mongoloid origin. In view of the evidence that many Mongoloid features are dominant in the hybrid, at least in the first generation (Hooton, '46), the logical conclusion is that not all of gene B could have been derived from a Mongoloid source.

(b) *Historic movements of peoples cannot explain B frequency in parts of western Europe and the Mediterranean.* Certain western areas have a B frequency of 0.076 or more. These are Ireland, Holland, Norway, Denmark, Tuscany and Umbria, Sardinia, parts of Northern Africa. Although the sample is small, Boyd and Boyd found a frequency of 0.108 in Wales, and Roberts found a frequency of 0.097 in 909 persons with Welsh names (quoted from Stern, '49). Even in Scotland, the frequency is 0.076, or 0.120 according to the data quoted by Wiener ('43). These levels would imply that, since the Mongoloid invasions, there has been enough population drift from the east into the territories named to introduce

25% or more of Mongolian genetic factors. This assumption does not seem to require further comment.

(c) *Mongoloid infiltration would have reduced the frequency of gene A.* Ascription of blood group B to Mongoloid infiltration ignores the fact that all the Mongoloid populations which are high in B are low in A. Those Mongoloids who have the highest frequencies of gene B average about 0.180 in gene A frequency; and it must not be forgotten that some of this may have been derived from slight hybridization with Caucasoids. The highest European gene A frequencies include the Lapps, many Finnish districts, and Sweden and Norway. Some populations in the Ukraine, as well as in Hungary, approach a frequency of 0.300. In spite of the fact that the Lapps show certain Mongoloid affinities, blood group B is infrequent among them; but in parts of Finland, where gene B is high (that is, about 0.160), gene A frequency is also very high, often about 0.330. If the B is derived from Mongoloids, this element in these populations would therefore approach 50%. The Caucasoid half of the population must, on this assumption, have had a gene A frequency of at least 0.480. This is improbable.

Fortunately, we are not dependent upon such indirect evidence to demonstrate that Mongoloid infiltration reduced gene A frequency. Evidence may be obtained from a territory which does contain a Mongoloid element. Coon's ('39) map of racial distribution indicates a western thrust of Mongoloids into European Russia north of the center, i.e., westward from Perm. The unweighted averages of the frequencies of genes A and B, for 8 series from the territory to the north and east of Moscow are 0.228 and 0.188, respectively (ranges, p, 0.199 to 0.268; q, 0.172 to 0.210). In contrast 14 series from the Ukraine, also including Rostov, yield averages of 0.278 and 0.159 respectively (ranges, p, 0.246 to 0.312; q, 0.131 to 0.208). The Mongoloids appear definitely to have lowered the frequency of gene A, and, probably, to have elevated B. In this summary the reason for taking the unweighted mean is, of

course, to prevent a long series, perhaps from an atypical locality, from obscuring the character of the region as a whole.

Even better evidence is found in the data plotted in figure 4. Excluding the relatively pure Mongoloid peoples, nearly all the populations listed by Boyd, beginning with the Cheremiss on page 218 and ending with the Zyrians on page 222, are White-Mongoloid hybrids, in which the proportions of the two elements vary greatly. It cannot be assumed that all the

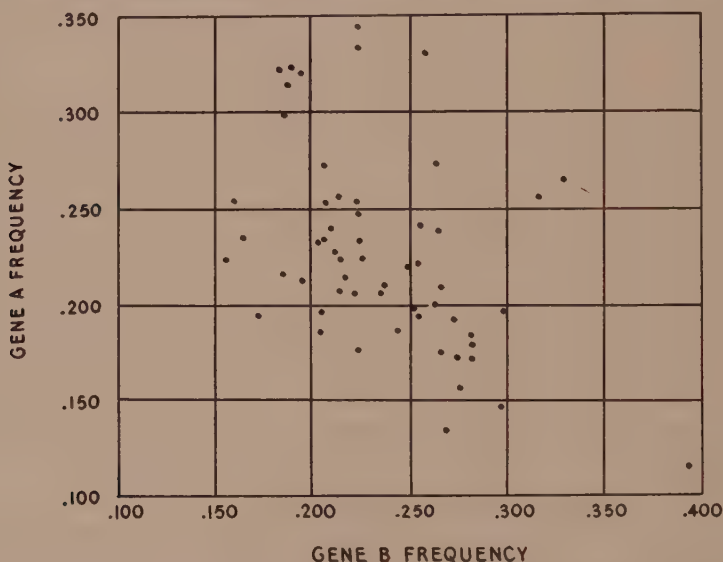


Fig. 4 Negative correlation between p and q in mixed, White-Mongoloid, populations: $r = -0.495 \pm .093$. In spite of the fact that more than one white racial type was probably represented, and possibly more than one Mongoloid type as well, the expected negative correlation appears. In general, as p increases, q decreases. Since r is over 5 times its probable error, it is almost certainly significant.

Caucasoid element is the same; it probably included at least two varieties of "Nordic" and also the "Mediterranean" element in the Tatars and Turks, together with Alpine in the Tajiks. Nor can it be assumed that the Mongoloid elements were uniform. Yet if, in general, the Mongoloids possessed many B genes and fewer A genes, whereas the reverse was true for the Caucasoids, then if p and q are plotted a negative correlation should appear; that is, where p is higher q should

be lower. The only omissions from Boyd's data for these populations were series where D/σ exceeded 2.5 and the Mongoloids included in figure 1. The negative correlation is surprisingly good in view of the heterogeneous elements which could have been involved, not all of which were named. The coefficient, $r = -0.495 \pm 0.093$. Since r is over 5 times its probable error, it is almost certainly significant. The slope of the regression line in the figure indicates (unless we assume wholly improbable gene frequencies in the original elements) that the white component in the hybrids usually possessed more or less of gene B.

The full weight of the evidence derived from the correlation of figure 4 is best appreciated if that figure is compared with figure 1. These figures, in fact, serve as partial controls, one of the other. The regression lines of the two figures are almost at right angles to each other, and this relationship is precisely what hybridization, with varying ratios of the two components, between a low-p-high-q population and a high-p-lower-q population must produce. Figure 4 also indicates that the correlation of figure 1 would have been better, had it been possible to pick Mongoloid tribes in whom the White element was negligibly small or absent.

It is evident, therefore, that a Mongoloid factor in Eastern Europe, sufficient to have raised q to the observed levels, would have caused much lower p levels than those which are found.

(d) *Derivation of gene B from Mongoloids ignores the strong evidence that it was earlier introduced by Neolithic invaders.* A strong case can be made for the view that certain Neolithic invaders must have brought a large proportion of the B genes into Europe. In making this analysis we shall tentatively assume that the interpretations presented in Coon's ('39) book are substantially correct, since in general Coon's views are strongly supported by the present interpretation of blood group frequencies. According to Coon the Finns (excluding the Swedish element) are predominantly derived from the Mediterranean racial type which introduced

Neolithic culture into Europe by way of the valley of the Danube River. They are called Danubian by him. The element of secondary importance in Finnish ancestry is the northern forest people, of which the type Coon calls the Ladogan is an example. The Lapps represent another one of these northern racial types. In addition to one, or possibly both, of these types, the ancestral Finns hybridized also, to a minor extent, with the proto-Nordic type Coon calls the Corded, and, in later times, with Swedes. The mixture is not uniform. In the southwestern and western parts of Finland the Swedish element is strong; elsewhere there are larger or smaller increments of the "Paleolithic" peoples. We shall now make an assumption. The Danubians had gene frequencies of p and q of about 0.340 and 0.220, respectively. Several studies of the Lapps permit us to infer that, before mixture, their gene frequencies were, very approximately, $p = 0.360$ or more and $q = 0$ or very low. The Swedish immigrants presumably ranged from $p = 0.240$ to 0.300 and q , about 0.070. We must speculate regarding the Ladogan type. Like the western European Upper Paleolithic men, it was probably low in gene A, and B was very low or absent. The evidence will emerge later. Now, if the Danubian received a Lappish element, A would be raised slightly and B greatly lowered. *A Ladogan element would lower both.* The Swedish element would usually lower A slightly and B much more. A Mongoloid element would produce the negative correlation of figure 4. Since the Ladogan element is the most important, outside the areas containing Swedes, a positive correlation between p and q levels should appear when the data for different districts are plotted, providing only that there is considerable variation from district to district in the magnitude of the Ladogan component in the populations. The scatter diagram is shown in figure 5. As expected, the correlation is not close: $r = 0.423 \pm 0.088$, but it is significant. It indicates that these two genes were associated in the predominant element in the Finns, namely, the Danubian, and it may readily be inferred that the frequencies were not very far different from those suggested above. If it should be

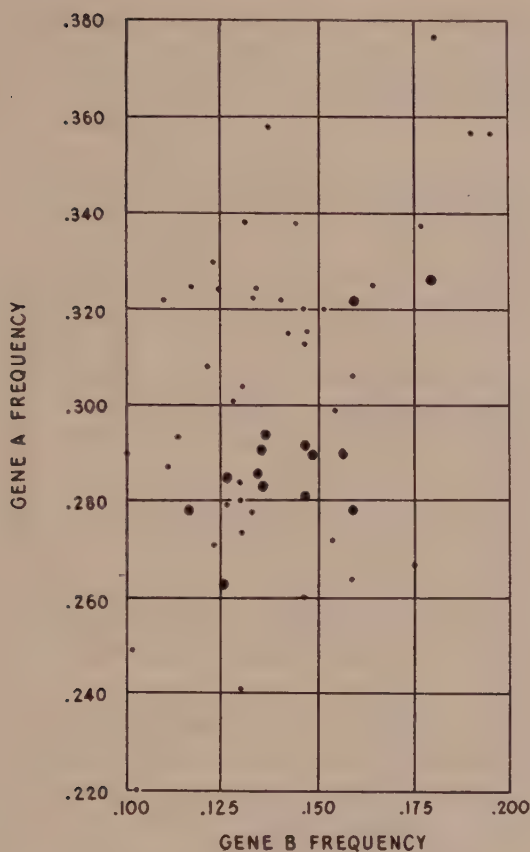


Fig. 5 Frequencies of gene A plotted against frequencies of gene B for all Finnish series of 150 individuals or over as reported in Boyd's tables, Swedish speakers being omitted. The larger solid circles are series of over 500 individuals, and are counted twice in calculating the coefficient of correlation, but only once in determining the probable error. The coefficient, $r = 0.423 \pm 0.088$. Since r is 4.8 times its probable error, the correlation is significant. Five series of Swedish speakers, two short, ranged from .225 to .343 in p and from .080 to .110 in q , a sixth unreliable series being omitted.

A word may be added regarding the validity of deriving r from such data as these. If the correlation was perfect in the populations from which these samples were taken, nevertheless, because of the statistical fluctuations in such samples, both in p and q , a coefficient of correlation derived therefrom would not be unity, but some lesser figure. It is obvious, therefore, that the significance of the correlation found in this figure is hardly less than that calculated.

shown that the phenotype in those Finnish districts which are relatively low in both genes A and B indicate a larger Ladogan element than in those districts where the gene frequencies are higher, the foregoing argument would receive powerful support.

These observations immediately give us the key for analysis of much of the blood group distribution in northern and northwestern Europe. As Coon ('39) has pointed out, the Iron Age Nordic was probably a hybrid in which the most important elements were the Danubian and the Corded. Let us, therefore, select a region in which this hybrid has mixed with the Upper Paleolithic. Sweden is a good example. We shall not be too far wrong quantitatively if we assume two parts Nordic to one part Upper Paleolithic, or a little less of the latter. If the Corded carried no B genes, then the Swedish level should be about $0.220/3$, or 0.073 . The actual level from Haldane's ('42) table is 0.072 ; and about 0.082 in Wiener's book ('43). Another example is England. Here the basic population is Keltic, with Upper Paleolithic and other larger or smaller elements. According to Coon ('39) the Keltic type was Iron Age Nordic with, probably, less Corded than the type in Sweden, but with Dinaric and Alpine accretions. It may have entered England with a B frequency of nearly 0.100 , which was reduced (barring London, in which there is a partly continental population) to about 0.050 or 0.060 by the autochthonous Upper Paleolithic, the Atlanto-Mediterranean (which can be shown probably to have lacked B), certain earlier Mediterraneans, and perhaps the Beaker People. Such levels are found in England outside the London and Liverpool areas (Weiner, '43). The later invasions would not have changed the situation greatly. A comparison of the English, German, Swedish, Norwegian, and western Swiss data suggests that the "Corded Nordic" probably had an A frequency of nearly 0.400 , and few or no B genes, if our inferences concerning the Danubian are correct.

Distribution of gene B in Europe. In the foregoing section the presence of gene B in northwestern Europe has been as-

cribed mainly to the Danubian element in the Iron Age Nordic. Where the survival of the Iron Age Nordic in living populations has been greatest, as estimated from Coon's ('39) map of racial distribution in Europe, the frequency of gene B is usually $.070 \pm .012$. These territories include eastern Ireland, England, Scotland, western Switzerland, southwestern Germany, southeastern Norway, Sweden. In Holland, the frequency is a little higher, being 0.088, and in Belgium it is lower, being 0.056. If we pool the data from these two populations, the usual level is obtained. The pooled data for the Dutch, as quoted by Wiener ('43) give $q = 0.060$.

Farther east in Europe, namely, in Finland, Esthonia, Latvia, Lithuania, Poland, Slovakia, Hungary, Yugoslavia, and most of European Russia, gene B frequency is usually within the range, 0.160 ± 0.025 . In most of these areas, as Coon indicates, a blend of the Danubian with a Ladogan type, which Coon calls the Neo-Danubian, is more or less strong, whereas the Iron Age Nordic is relatively weak. Again the implication of the facts is that much, if not most, of the gene is derived from the Danubian. This statement does not deny that some fraction of the B genes has been derived from Mongols, but it must be noted again that in the Ukraine, which was the corridor for the Mongol invasions, and in Hungary, where the Mongoloid element has left strong morphological traces, the frequency of the gene is actually lower than it is in some more typical parts of Neo-Danubian territory. Of course, when we move farther eastward, to the Astrakhan region and Perm, where the population is partly Mongoloid, the frequency increases to about 0.220. But in these regions, it is fair to assume that some percentage of the genes is also derived from Danubian or other purely "White" racial elements, as figure 4 strongly suggests.

Turning to southern Europe, where no important Mongoloid or Danubian element can be assumed, the frequency of gene B ranges from very low, possibly originally zero, in the Basques to 0.131 in Apulia, in southern Italy. Yugoslavia is here omitted because of the Slavic immigration. Madrid appears to be low in gene B, but in Barcelona the reported level was 0.069

(Haldane, '40). In northwest Africa the level often exceeds that in Apulia, and in Egypt it rises to 0.200 or more. Some of the B genes in the Mediterranean region may be ascribed to historic invasions from the Near East but, as in northwestern Europe, these probably cannot explain the observed frequencies. The source was probably a Mediterranean invader, comparable to the Danubian.

Our next problem is to attempt to identify the race which introduced gene B into the Mediterranean region. During the Neolithic, the Merimidian people appeared in the Egyptian delta, and on cultural grounds Coon ('39) inclines to the opinion that they later entered Europe by way of Gibraltar, whence the Neolithic economy was spread to the Swiss lakes and the Rhine, and here the invaders presumably met the Danubians. These people were apparently classical Mediterraneans. It may be assumed that they are an important element in the population of Spain, Portugal and France; but their type is probably less important in Southern Italy and Sardinia, where the higher B frequency is found. Tentatively, they may be excluded as bearers of the gene.

Another Neolithic invader is called the Atlanto-Mediterranean by Coon. This people came by sea, and according to Coon's map, are an important element in the populations in Ireland, England, Wales, France, Spain, Portugal, Northern Italy, Greece, Bulgaria, and Western Anatolia. According to Coon, they are a major element, together with other Mediterraneans and Dinarics, in the Basques, who possess a minimum of gene B, and elsewhere the gene can be attributed to other peoples. This race can probably be definitely excluded as a gene B bearer.¹ The Pontic Mediterranean, allied to the Atlanto-Mediterranean, is strong in the Ukraine (Coon, '39). It is quite possible that its lack of gene B is the reason this gene is not more frequent in that region, and also in Rumania and Bulgaria. It appears, therefore, that we may have to seek for gene B in earlier immigrants.

¹ This conclusion is strengthened by data from Hooper ('47). In southeastern Ireland, where Coon finds maximum Atlanto-Mediterranean survival, q in Wicklow and Wexford is suggestively lower than in other parts of Ireland.

The Danubian seems to have differed from the Mediterranean types just discussed in having a wider nose, a less dolichocephalic skull, and in other features. During the Mesolithic, the Mediterranean Natufians of Palestine also possessed wider noses, together with prognathism, and a somewhat similar type entered Portugal late in the Mesolithic or early in the Neolithic. A rather wide-nosed, prognathous, small Mediterranean, the Badarian, was present in Upper Egypt about 4000 B.C. In Switzerland during the Neolithic, and probably extending into Italy, were the Chamblandes people, who also were not classical Mediterraneans (Coon, '39). It is not implied that all these peoples were alike, but they may have contained a common element, which had introduced gene B. It is suggested, therefore, that, aside from the contributions of later invaders, gene B throughout the Mediterranean region was introduced during the Mesolithic by a Mediterranean, which was not of the classical type. Wales probably contains such an element. Although the data for Ireland indicate a gene B frequency of 0.071 (Hooper, '47), which may possibly be entirely a Danubian contribution, it is likely that here, too, the Mesolithic Mediterraneans are also involved, and the same conclusion applies in Scotland and Liverpool. In Iceland the frequency is about 0.062.

It is fully recognized that much more evidence is needed regarding the gene B carriers in southern Europe, and along the western coasts. A careful comparison of relevant morphological features and serological data in enough population samples should, however, make a definite conclusion possible.

The probabilities in figure 3 were calculated by Miss Ethel L. Eaton, and the figures drawn by Miss June Hill.

SUMMARY

It is shown that, both among Mongoloid tribes and in Africa, among Negrillos and Negroes, a significant correlation exists between the frequencies of genes A and B; that when allow-

ance is made for gene A in the proto-Negritoid component in the African population, and for A from a Caucasoid element in the Mongoloids, the residual p/q ratio appears to be a little less than one-half; that a suggestive trend of the same sort is also observable in India and in Indonesia. It is noted that in Africa, gene B frequency is often high also in the populations which apparently contain little or none of the Negritoid element, and a somewhat analogous situation exists in Asia; and it was seen that a correlation between A and B frequency is found in Finland.

It is concluded that the most probable explanation of these correlations is that in each of these regions the same primary (or ancient secondary) race brought in all of the B genes, and more or less of the A genes; that this race is everywhere hybridized with one or more other races; but that in each of the tribes or populations from which blood group samples were obtained, the percentage of the B-carrying race differed more or less from the percentage in the other populations, and that the correlations are due to this. No other explanation is proposed because no reasonable alternative has been found, when all the evidence is considered. It is suggested that the B bearer was a "Mediterranean" subrace.

In the second part of the paper four reasons have been advanced to show that European blood group B could not have been introduced in large part by invaders of a racially Mongoloid type. These are: (a) Such a source would imply a 50% Mongoloid infiltration in populations, which betray little physical evidence of a Mongoloid element; and in those areas where such an element is present, the frequency of gene B is often lower than it is elsewhere. (b) Historic movements of peoples cannot explain gene B frequency in parts of Western Europe and the Mediterranean, if the Mongoloids were its source. (c) Mongoloid infiltration would have reduced the frequency of gene A, yet in some regions where B is high, such as parts of Finland, the frequency of gene A approaches the European maximum. (d) Derivation of gene B from Mongo-

loids ignores the good evidence that certain Mediterranean Neolithic invaders must have carried the gene.

A brief discussion is given of gene B distribution in Europe, with speculation regarding its carriers into the Mediterranean region and the Western littoral.

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BODY-WEIGHT/BODY-SURFACE RATIO.—In the course of biometrical work concerning twenty different human samples—the individual figures partly obtained by myself and partly taken from other sources—I have found the following values for the body-weight/body-surface ratio (kg/m^2):

<i>Men</i>	<i>Average</i>	<i>σ</i>
72 French workers	37.99	1.93
75 French soldiers	37.88	2.10
107 Italian soldiers (natives of Sicily)	37.43	1.86
37 Albanians	37.05	1.97
70 men from Southern Europe (Mediterranean countries)	36.93	1.75
21 Arabs (Yemen)	36.01	1.47
99 Annamites (French Colonial troops)	36.02	1.30
124 Somalis Darod	35.09	1.78
117 Somalis Rahanoween	34.67	1.73
87 Somalis Hawiyah (Haweeah)	34.42	1.54
47 Somalis Dir	34.42	1.77
50 Negroes Gobaween (Somalia)	34.71	1.67
107 Otomis (Mexico)	34.98	1.83
19 Berbers (Giado)	35.41	1.75
25 Daouad (Fezzan, North African desert)	33.92	1.20
40 Andamanese	32.42	1.71
<i>Women</i>		
54 Parisians	35.83	2.68
34 Rahanoween	37.92	2.05
15 Gobaween	37.43	1.53
36 Andamanese	33.35	2.32

There is obviously a decline of the value of the ratio as we proceed from temperate to tropical regions. Of course, ratios do not follow exactly either latitudes or isotherms—such would be indeed surprising—but the general tendency is clear . . .

Now the ratio weight/surface plays a part in the regulation of body-heat. In a hot climate a relative deficiency of body-mass—or relative excess of body-surface—is an advantage . . .

. . . we must admit at the same time the interference of an independent sexual factor, for the position is not the same with women . . . It must be remembered that, in women, heat regulation does not work in exactly the same way as in men.

A full account of these findings, together with a detailed anthropometrical body-build analysis, of eleven kinds of males and three kinds of females, will be published in *l'Anthropologie*.—Eugène Schreider. Geographical distribution of the body-weight/body-surface ratio. *Nature*, vol. 165, no. 4190, Feb. 18, 1950, p. 286.

HAIR TEXTURE: ITS DEFINITION, EVALUATION AND MEASUREMENT

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“Hair texture” is a quality frequently included among the morphological observations made during anthropometric studies, and it is often listed as a characteristic useful in human taxonomy. Ratings of hair texture are available for a number of populations, population sub-groups, and for groups with varying degrees of recent admixture. Yet, despite the frequent appearance of the term hair texture in the American anthropological literature, it is difficult to find a satisfactory definition of the term, description of the categories that can be distinguished, or attempts to test the reliability of the ratings.

DEFINITION OF HAIR TEXTURE

Ripley ('10, p. 457) considered hair texture to be identical with hair form, for he wrote: “The two extremes of hair texture in the human species are the crisp, curly variety so familiar to us in the African Negro; and the stiff, wiry hair of the Asiatic and the American aborigines.” More recently Kroeber ('48, p. 129) used the term in much the same way and after referring to Pruner-Bey’s attempted correlation of hair form and the cross-section index, he makes the interesting statement that “hair texture seems to run rather rigidly along hereditary, racial lines, and to be uninfluenced by factors of age, sex, climate or nourishment.” Turney-High follows Kroeber very closely, and distinguishes three categories of hair texture (in terms of hair form) and also asserts that hair

is a true racial character, hereditary, and unaffected by environment, age and sex (Turney-High, '49, p. 22).

Those who use the term hair texture to describe hair form are in the minority, however, and a larger number of anthropologists apparently make the term synonymous with hair thickness, and consider hair form a separate variable. Though Hooton does not define the term in *Up from the Ape*, the Harvard anthropometric blank reproduced on page 750 of that work contains, under the morphological observations, three categories for texture: coarse, medium and fine (Hooton, '46), and Hooton states (personal communication) that the term texture as used by him always refers to the coarseness or thickness of the hair. Davenport's short guide to anthropometry also listed three categories of hair texture—soft, intermediate and coarse, and he reprinted an earlier version of the Harvard blank with the same three categories mentioned above (Davenport, '27, p. 50). While Hrdlička did not define hair texture in his manual (Hrdlička, '39), he used the categories coarse or thick, medium, and fine in his study of Old Americans, and in his report on members of the National Academy of Sciences (Hrdlička, '25, '40). Krogman, in his essay on the concept of race, refers to the same three categories of hair texture (Krogman, '45, p. 50) and Herskovits has adapted the table containing those categories in his recent text (Herskovits, '49, p. 147). Anthropologists trained by Hooton rate texture independently of form, and use the same three categories (Williams, '31; Seltzer, '36; Lasker, '46; Kelly, '47; Angel, '49; Gabel, '49). Investigators who have made microscopical studies of hair also use the term texture as a synonym for thickness, but sometimes extend the term to include cross-section area, and even hair weight as well. The Woodburys used the term "texture" in a slightly more restricted sense to refer to the average thickness of the hair (Woodbury and Woodbury, '31; Steggerda and Seibert, '41) and they distinguished but two categories, coarse and fine. In

general, however, the word texture as applied to hair is approximately equivalent to the German term *Dichtigkeit*, and three categories are distinguished.

COMPARISON OF OBSERVATIONS

Having established the more common use of the term hair texture, and the three categories usually distinguished, it is of interest to determine whether observations of hair texture are reliable. This can be done by contrasting the findings of anthropologists who have rated samples from the same population, as well as by contrasting the findings of anthropologists who have rated adjacent groups.

Turning first to Hooton's criminal survey, where the morphological observations of two similarly-trained field-workers are contrasted, we find that Hooton has termed hair texture as a "grade D" observation (Hooton, '39). The comparison included 2823 males rated by observer A, and 1343 males rated by observer B. Observer A reported coarse hair in 54.10%, medium hair in 20.34%, and fine hair in 25.56%. Observer B found 18.02%, 72.08%, and 9.90% of coarse, medium and fine hair respectively. It is obvious that the two distributions are highly dissimilar and that the differences far exceed any attributable to sampling error or minor population changes.

Comparable differences, though not between observers trained in the same laboratory, can be found between Hrdlička's ratings on Old Americans, and Bell, Beise and Hughes' series of Michigan college girls. Hrdlička reported hair thickness to be "about medium with an occasional tendency to moderate fineness" (Hrdlička, '25), without giving percentages. Bell, Beise and Hughes ('41) on the other hand, reported coarse hair in 10.21%, medium hair in 52.05%, and fine hair in 37.74%. It is interesting, however, to find that Angel's ratings on the somewhat older Philadelphia women do not differ markedly from the Michigan data (table 1).

Striking apparent differences between groups that would be expected to show similarities are also found in studies on the

TABLE 1
Comparison of ratings of "hair texture" on 12 groups

GROUP	INVESTIGATOR	SOURCE	PERCENTAGE DESCRIBED AS		
			Coarse	Medium	Fine
1. American criminals ¹	Observer A	Hooton 1939	54.10	20.34	25.26
American criminals ¹	Observer B	Hooton 1939	18.02	72.08	9.90
2. Michigan college girls	Bell, Beise and Hughes	Bell, Beise and Hughes 1941	10.21	52.05	37.74
3. Obese Philadelphia women	Angel	Angel 1949	11.76	46.08	42.16
4. Howeitat Bedouin	Shanklin	Shanklin 1946	60.87	10.14	28.99
5. Beni Sakhr Bedouin	Shanklin	Shanklin 1946	37.29	23.73	39.00
6. Syrians	Cline	Seltzer 1936	9.96	59.39	30.65
7. Armenians	Coon et al.	Seltzer 1936	14.74	81.05	4.21
8. Mexicans (prisoners)	Kelly	Kelly 1947	66.66	19.05	11.61
9. Yucatan males	Williams	Williams 1931	91.1	8.9	0.0
Yucatan females	Williams	Williams 1931	82.5	17.2	0.3
10. Papago	Gabel	Gabel 1949	93.61	6.39	0.00
11. Yaqui	Seltzer	Gabel 1949	7.00	25.00	68.00
12. Chinese (Immigrant) ²	Lasker	Lasker 1946	78.4	18.6	3.1
Chinese (Am. born) ²	Lasker	Lasker 1946	89.6	8.3	2.1

¹ American-born Whites of American parentage from adjacent states. Sample size 2823 and 1343 respectively.

² Chinese-born Cantonese, and American-born Chinese of Cantonese parentage.

American Indian. Gabel compared his ratings on 219 Papago males to Seltzer's ratings on Yaqui, Zuni, Hopi, and Navajo (Gabel, '49). Gabel recorded coarse, medium and fine hair respectively in 93.61%, 6.39% and 0.0% of Papago, while Seltzer's series of Yaqui, Zuni, Hopi and Navajo all showed maxima in the "fine" category. The Yaqui, closest to the Papago in most characteristics (according to Gabel), were totally unlike them in the hair texture ratings, with 7%, 25% and 68% of coarse, medium and fine hair respectively. While there is evidence that the Navajo hair is finer than that of some other Indian groups (Woodbury and Woodbury, '32; Steggerda and Seibert, '41), it is highly unlikely that differences of the magnitude reported are real. Hence the reliability of the ratings is again in question.

Despite discrepancies in ratings on both Whites and Indians, some of the reports indicate agreement among observers, and findings in accordance with micrometric investigations. Coarse hair, for instance, is reported in a majority of Chinese (Lasker, '46), Yucatan males and females (Williams, '31) and Mexicans (Kelly, '47) and is also reported for a number of Indian groups, but without stating percentages. While it is possible that these findings were influenced by the general belief that Chinese and Indians have a predominance of coarse hair, they do suggest the use of comparable standards.

Evidently, there are both concordances and discordances in observations on hair texture, and the magnitude of some of the differences is so large that in general little weight can be attached to this observation. The immediate problem is why this particular observation is such an unsatisfactory one, in contrast to observations on iris pattern, or forehead slope (cf. Hooton, '39, p. 62). There are two possibilities to be considered. First, the observation depends upon the sense of touch, and it is possible that there are marked differences in tactile sensitivity, so that what feels "coarse" to one observer feels "fine" to another. The other possibility is that judgment, rather than perception, is at fault, and that observers

differ in the limits they set to the categories coarse, medium and fine.

COMPARISON OF DISTRIBUTIONS

Since present evidence from microscopical studies indicates that hair thickness follows a normal distribution, and that variance does not differ greatly from group to group,¹ it is possible to inspect the findings of various observers, and to obtain some idea of the limits set for the three categories. In still-unpublished data from the Harvard Irish study, Dupertuis, who was responsible for the anthropometry of the males, placed approximately 90% in the medium or intermediate category of hair texture. Since there is no reason to believe that the Irish are markedly less variable in this respect than other groups, the medium category as used by Dupertuis must be a broad one (cf. Hrdlička, '25, '40). Presumably the medium category as used by observers B and Coon et al. (Seltzer, '36) was equally broad, assuming a slight excess of coarse hair in their series (table 1). On the other hand, the proportions of coarse, fine, and medium hair begin to approach equality in the data of Angel, '49), Bell, Beise and Hughes ('41), and observer A (Hooton, '39), suggesting either greater variability in their samples, or (more likely) narrower limits of the medium category. Shanklin's data introduces a new feature, bimodality; in both his Howaitat and his Beni Sakhr, there are fewer individuals in the intermediate category than in either the coarse or fine categories (Shanklin, '46). Since it is highly unlikely that measurements of hair thickness would show a bimodal distribution, it is probable that the medium category as used by him had relatively narrow limits.

Thus the evidence would favor the suggestion that some of the discrepancies noted in the literature are due to differences in the limits assigned to the three categories by different observers. Some apparently consider the medium category to be broad and inclusive, others presumably make the limits of this category equivalent to the $\pm 1 \sigma$ range, while still others use

¹ The coefficient of variation is about 20% for both diameters, slightly less in the female.

the medium category only for hair that can be considered neither fine nor coarse. That such differences in judgment should exist can be explained by the absence of standards of comparison (like the Fischer-Saller Haarfarbentafel) and by the fact that the few attempts that have been made to describe the feel of coarse, medium and fine hair have not been notably successful.²

ALTERNATIVE METHODS OF RATING HAIR TEXTURE

While the present method of rating hair texture has not proved reliable, there are marked racial and individual differences in hair thickness, and such differences can be felt, and they can be measured. It is possible, therefore, to go beyond the stage of criticism and to suggest alternative methods of rating hair texture. As has been noted, the present categories are ill-defined, and there are no standards for field use. Therefore, one alternative is to define the metric limits of the categories, and to develop standards of comparison. The second alternative is to abandon hair texture as a field observation, and to replace it by the laboratory measurement of hair samples collected in the field, as has been done by some workers. The third alternative is to use hair weight as the criterion of hair thickness, since the two are highly correlated.

FIELD STANDARDS

Data presently available indicate that human head hair varies between 25 μ (.025 mm) and 125 μ in thickness. Finest adult head hair averages well below 60 μ , head hair from Whites in general averages about 70 μ , and head hair from Chinese and Japanese averages about 90–100 μ , with variability in each case approximately 20% of the mean (i.e. from 10 to 20 μ). Hence, it would be possible to set arbitrary limits for the three categories as: fine, $x < 56 \mu$; medium, 57

² Schmidt for instance defines the categories coarse and thick as follows: "Fein nennen wir im Allgemeinen ein einzelnes Haar, wenn dasselbe nur undeutlich zwischen den Fingern gefühlt wird: fühlt man es sofort deutlich, so nennen wir das Haar 'Dick' " (Schmidt, 1888, p. 139).

to 84 μ , and coarse, 85 — $x \mu$ and to devise field standards made of samples of hair or synthetic fibers of appropriate thickness, constructed along the general lines of the Fischer-Saller Haarfarbentafel. Field workers who employed such an aid would at least have a common standard of reference, and while it would still be necessary to decide which of the three numbered samples resembled the subject's hair in each case, marked individual differences in the definition of the categories would be largely eliminated.

The author constructed an experimental model, along the lines described, in 1946 and found that it was fairly satisfactory in most cases. However, Negro hair provided difficulties in rating, partly because of the spring-like consistency of the spiral tufts, and partly because the difference between the minimum and maximum diameters cannot be represented in a single impression of texture.³ Thus assigning definite limits to the categories, and constructing standards of comparison for use in the field, are both practical, but may not be the final solution to the problem.

HAIR MICROMETRY

The second alternative to the present method is to measure hair thickness directly, since it is agreed that thickness is the variable in question. The problem of measuring hair thickness has been attacked by a large number of workers, including several anthropologists, and while there are differences in opinion as to which shaft diameter is the most representative measure,⁴ the techniques are highly reliable, whether measurements are made in optical section or in cross section, and results of various workers agree closely (Steggerda and Seibert, '41).

³ This difference in the two diameters of the cross section may be responsible for the fact that Negro hair has been variously described as coarse, medium, and fine in different texts.

⁴ Different workers have used the average diameter, the maximum diameter, and the mean cross-section diameter $\frac{\text{larger} + \text{smaller}}{2}$ (Woodbury and Woodbury, '32; Wynkoop, '29; Trotter and Dawson, '34; Steggerda, '40).

In general the procedure is to collect hair samples (taken at vertex) in the field, and later to defat a number of hairs from each sample, embed them in a supporting medium, make cross sections, and then to measure the mounted sections using a filar micrometer, a "comparator" or the "spirascale." Since the original studies reported in this journal, many aids and simplifications have been devised (Fiala, '30; Kneberg, '35; Steggerda, '40, '42; Trotter, '43; Garn, '47; Trotter and Duggins, '48).

Mechanical micrometry, though not discussed in the recent literature, is also practical, and requires considerably less equipment and preparation, since cross sections are not required. The author experimented with the use of a ratchet-head machinist's micrometer calibrated in ten-thousandths of an inch, and obtained results highly comparable to those attained by optical micrometry. While mechanical micrometry cannot equal optical micrometry in reproducibility of results, or in the amount of information provided, it nevertheless may appeal to some workers because it is simpler and more rapid.

HAIR WEIGHT

The third, and possibly most attractive alternative to the present method of rating hair texture, is to measure hair weight, and report the results as weight per-unit-length. Since, with length held constant, weight increases exponentially with thickness (as the square of the radius) and directly with cross-section area, weight is a good measure of thickness, and the theoretically high relationship has been borne out in practice by correlations as large as $+ .98$ between cross-section area and weight. This relationship has additional value when the form of the section departs markedly from a true circle, for there is no problem (as there is in measuring thickness) as to which diameter expresses size the best.

The technique of weighing hair is fairly simple. Starting with a hair sample (taken at vertex), 50 to 100 cm of hair is removed (10-20 hairs), defatted, dried to a minimum water content, weighed in a suitable balance, and the weight cor-

rected for length (Bernstein and Robertson, '27; Kneberg, '36; Trotter, '36).

Since hair weight varies from about .01 mg per cm to .1 mg per cm (.00001 to .0001 gm), a 50 to 100 cm length of hair will weigh between 0.5 and 10.0 mg, thus necessitating a balance sensitive to at least .05 mg. While such balances are available in larger institutions, anthropologists interested in this work can construct a simple Salvioni-type balance, as illustrated in principle by Seaborg ('46). Such a balance is simply a quartz or glass fiber, anchored at one end, and sufficiently fine so that a set minimum quantity will cause an appreciable deflection at the free end. Since the deflection is proportional to the load in such a balance, problems of calibration are reduced to a minimum.

The Salvioni-type balance is mentioned here, because the author has experimented with a home-made balance of this type, and succeeded in weighing individual human and simian hairs by bending them and hanging them at the free end of the fiber. Thus the absence of a sensitive beam-type balance need not deter workers from using hair weight as a routine measurement, especially since racial differences are marked, and preliminary studies of the inheritance of hair weight have already been made.

SUMMARY

1. The term "hair texture" has been used in several ways by American anthropologists. While a few have made hair texture a synonym for hair form, the majority employ it as the equivalent of hair thickness.

2. The conventional method of estimating hair texture by feel, and then assigning the impression to one of three categories (coarse, medium and fine) has been far from successful. Extraordinarily large interpersonal differences in observation exist, making the comparison of published ratings unwise. Observers trained in the same laboratory, may report differences as large as 80% in one category when rating similar groups.

3. A study of the proportions of coarse, medium and fine hair reported by different observers shows that some use the medium category almost exclusively, others tend to assign equal numbers to each of the three categories, while still others use the intermediate category only for doubtful cases. Thus discrepancies are due more to lack of standardization of the categories, then to inability to distinguish the various grades of hair thickness.

4. Three alternative methods are offered to the present method of evaluating hair texture. The first involves the definition of the three categories, and the development of a hair texture scale similar to the present Fischer-Saller scale. The second alternative is to measure thickness, the variable in question, by mechanical or optical micrometry as has been done by a number of workers. The third and possibly most attractive alternative, is to measure hair weight since it is highly correlated with cross-section area, and presents the fewest problems of preparation and measurement.

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LIMB BONES OF PROCONSUL.—Among the specimens collected from the Miocene deposits in Kenya are some limb bones which are clearly referable to a large primate comparable in size to *Proconsul nyanzae*. These include portions of two femora, the shaft of a humerus, part of a clavicle (all found in close association), a calcaneus and talus clearly belonging to the same individual, and an isolated talus. Unfortunately, none of these specimens was found in direct association with teeth and jaws, so that their specific identification must remain uncertain. However, they were recovered from the same series of deposits which have yielded many teeth and jaw fragments of *Proconsul*, and in size they appear to conform with *P. nyanzae*. For this reason they have been provisionally assigned to this species. All these limb bones are closely similar in their general dimensions to those of a large chimpanzee but in many details of their construction they show a closer approximation to the cercopithecoid limb skeleton than to that of the modern large apes. These details include certain features of the neck of the femur and the lesser trochanter, the presence of a well-marked dorsal tubercle on the neck of the talus and of a cup-shaped socket at the anterior end of the facet on this bone for the medial malleolus (both of which features allow for a firm “locking” of the ankle-joint in extreme dorsi-flexion), and the proportions of the calcaneus. When the talus and calcaneus are articulated together it becomes evident that the foot skeleton did not permit of the extreme degree of inversion of which it is capable in the modern large apes. In addition, the strongly marked impressions for ligamentous attachments on these bones, and particularly the deep notch on the lower aspect of the facet on the calcaneus for the cuboid bone, indicate that the tarsal bones must have been bound together in a firmly knit mechanism such as is required for quadrupedal functions rather than for the extreme mobility of the foot associated with exclusively arboreal habits. Lastly, the straightness and slenderness of the shafts of the humerus and femur indicate a creature much more lightly built and agile than the modern large apes.

If all the morphological evidence presented by these limb bones is considered in detail, and if it can be taken as applicable to the *Proconsul* group as a whole, it now seems clear that these Miocene apes were certainly not adapted for a brachiating mode of life. On the contrary, they appear to have been active, running and leaping creatures adapted rather for a quadrupedal type of locomotion like the modern cercopithecoid monkeys. This inference, of course, fits in quite well with the cercopithecoid characters already noted in the skull and brain of *P. africanus*.

The morphological evidence of the skull and limb bones, to which I have briefly referred, is of considerable importance for the problem of the evolution of the Hominoidea. For, if the estimate of early Miocene for the age of the East African deposits is correct, it means that the anthropoid apes which were in existence at that time were still extremely primitive, in the sense that they retained many characters corresponding to a cercopithecoid level of evolution. From time to time comparative anatomists have drawn attention to the structural contrasts in the limbs of modern Man and the modern anthropoid apes, and have even sought to argue on these grounds that Man could hardly have been derived from an anthropoid ape ancestry. But they appear to have assumed that the early anthropoid apes of Miocene times had already developed highly specialized limbs in adaptation to arboreal brachiating habits. It now seems clear that the limbs of the early Miocene hominoids were of a sufficiently generalized character to have allowed for the subsequent evolutionary development, along divergent lines, either of the specialized limb pattern which has been acquired by the modern Pongidae, or of a type of limb structure which might have permitted the gradual acquisition of an erect posture characteristic of the Hominidae.

One other interesting point emerges from the study of the limb bones. It appears that in both *Limnopithecus* and *Proconsul* the limbs had not undergone the degree of specialization which the modern apes show in relation to their characteristic arboreal mode of life. If these genera are accepted as early representatives of the two sub-families Hylobatinae and Ponginae, it must then be inferred that these branches of the hominoid sequence probably separated in their evolutionary history before developing their brachiating habits with all the associated structural modifications. In other words, it would seem that these modifications developed independently in the gibbons and the large anthropoid apes.—W. E. Le Gros Clark. New palaeontological evidence bearing on the evolution of the Hominoidea. Quart. J. Geol. Soc. London, vol. CV, pp. 225–264.

AGE CHANGES IN HEAD HAIR FROM BIRTH TO MATURITY ¹

III. CUTICULAR SCALE COUNTS OF HAIR OF CHILDREN

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TWO FIGURES

The outer surface or cuticle of hair is a highly keratinized substance arranged like scales with the free borders directed toward the distal end of the hair. The scale pattern was found by Eddy ('38) to be different for each of several hundred individuals. He also noted similarity of scale pattern in several families. The inverse relation between scale diameter and hair shaft diameter was pointed out by Hausman ('25). Wynkoop ('29) studying another series of hairs under Hausman's direction, supported the earlier finding of an inverse variation of scale diameter with shaft diameter and found no correlation between scale diameter and age.

Scale count is considered by Kirk ('40) to have a very considerable value both in the description of hair and as an eliminative factor in the identification of an individual. In the following year Gamble and Kirk ('41) published a statistical study of scale counts on 39 samples of human crown hair in which they stated: "a single hair was found to be characteristic of all hairs counted for the individual with respect to mean and nearly always to range of scale counts" (p. 631). Their hair samples were taken from 37 individuals all of whom are assumed to be White excepting one who was "part Indian." There were 8 females and 29 males in the group and

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² In partial fulfillment of the requirements for the degree of Doctor of Philosophy.

for 8 of the males no age was given except in the case of two who were said to be middle aged. The remaining 29 subjects ranged in age from 19 to 37 years. For two subjects two different samples of hair were studied: in one case, a sample which had been permanently waved and another which had not; in the other case a sample which had been taken at 21 months and another at 23 years.

This paper presents a statistical analysis³ of scale counts made on hair of children from birth through 14 years of age, and an evaluation of the hypothesis that scale count is an eliminative factor in the individualization of hair.

MATERIAL AND METHOD

The hair samples are from the same group, 9 girls and 7 boys, on which studies of index, cross-sectional area and percentage incidence of medullation have been reported (Trotter and Duggins, '48; Duggins and Trotter, '50). Briefly, they are 16 White children, of which 5 pairs are siblings including one pair of identical twins and two pairs who are first cousins. They were born between 1930 and 1942. Monthly samples from the vertex beginning at birth are on file; however, only the first sample and every 12-month sample thereafter through 14 years have been examined for scale count.

The method of counting the scales is comparable in its essentials to that described by Gamble and Kirk ('41). The hairs were mounted on a slide by holding down either end with Scotch tape. Care was taken to avoid stretching. A drop of an equal mixture of alcohol and glycerine was placed at either end of the hair. These drops moved along the shaft by capillary attraction and brought into better relief the free borders of the scales (fig. 1). An ocular micrometer was utilized and found to cover on the slide a distance of 0.16 mm with a magnification of $\times 120$. The ocular micrometer was oriented so that one of its sides paralleled and overlay the long axis of the

³ Grateful acknowledgment is made to Dr. Goldine Gleser who analyzed the statistics and also guided us in types of counts needed for a critical evaluation.

hair. Within this given straight line distance the free edges of all the scales crossed by the ocular micrometer were counted. This provided a figure which is referred to as one "scale count." In order to make a direct comparison with the counts of Gamble and Kirk it will be necessary to convert this value to that for 0.2 mm of length by multiplying by 1.25.

In view of Gamble and Kirk's findings, viz., that a single hair is characteristic of all hairs counted for the individual, one hair from the one-month and each 12-month sample thereafter was utilized to make comparisons between individuals

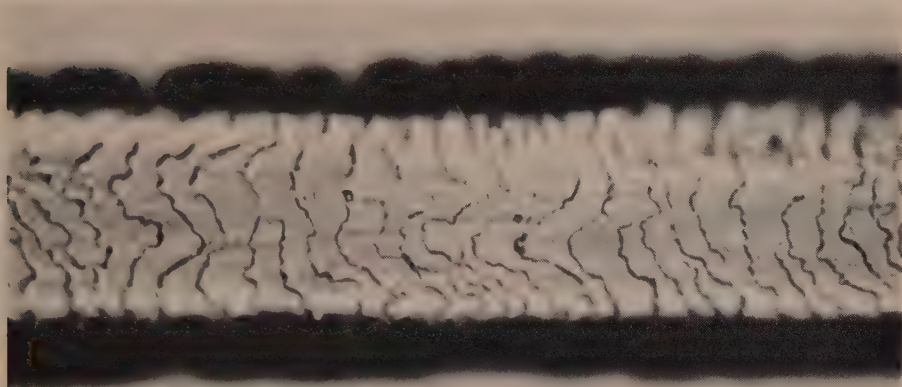


Fig. 1 Surface of hair to show cuticular scales, $\times 670$.

and between ages. The hair was selected at random and on it 100 counts were made at different locations along the shaft. This procedure was carried out for each of the 16 children beginning with the first sample after birth and extending through 14 years for every child who has reached that age, otherwise for the extent of his age. In addition, for further comparisons between individuals and between ages, three other series of counts were made on certain unrelated subjects: two counts on each of 10 hairs from each 12-month sample beginning at one month and extending through 14 years were made for subjects A, B, C, D and E; 50 counts on each of 10 hairs from

the 4-year and the 10-year samples for subjects A, B, H, L and O; and, finally, two counts on each of 50 hairs from the 1-, 3-, 5-, 7-, 9-, 11- and 13-year samples for subject C. All counts were made by the same individual (O.H.D.).

RESULTS

The mean, the standard deviation and the actual range of each series of scale counts for each sample studied are recorded in table 1. The expected or theoretical range can easily be determined ($M \pm 3 \times \text{S.D.}$). The actual range lies within the limits of the theoretical range in almost all instances (95.6%).

Age and individual differences. The means of the scale counts (100 counts on 1 hair from each sample) for each of the 16 children are represented in graphs according to age in figure 2. The graphs for the 5 pairs of siblings are placed side by side and in a general way show similarities in range between members of the same pair, the least similarity being present in the case of subjects E and N. However, the graphs for the unrelated subjects are as similar in some cases as are the graphs for the related subjects (cf. G and I). Each graph shows much irregularity and no consistent trend with age. The graph for the composite means of all subjects according to age substantiates this fact. On the other hand, there are individual differences in range.

An analysis of variance (table 2) indicates a highly significant individual difference in scale count but the difference between age groups provides an F ratio which is barely significant at the 5% level (Snedecor, '46). The lowest averages according to age are at 11 and 12 years, respectively, for which only 10 subjects have provided data in each case. Since all 16 of the subjects have not reached an age of 14 years this analysis is based on an incomplete matrix.

In order to obviate any possible effect of the incompleteness of the matrix on the validity of the result another analysis was made on the complete matrix which involved data pertaining to 15 subjects, A through O, for the period from birth

Mean, standard deviation and actual range according to various types of scale counts¹ for each child from birth through 14 years of age

TABLE 1

SCALE COUNTS OF HAIR OF CHILDREN

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AGE	TYPE OF COUNT	M	S.D.	A.R.	M	S.D.	A.R.	M	S.D.	A.R.	M	S.D.	A.R.
Subject A													
B	100 (1)	21.6	1.5	19-25	22.5	1.5	20-26	21.3	1.7	17-25	21.0	1.2	19-24
	20 (10)	21.6	1.2	20-24		1.7	20-26		1.8	16-21		2.8	15-27
1	100 (1)	20.7	1.6	18-25	20.9	1.3	18-23	18.8	1.1	16-22	22.2	1.3	20-25
	20 (10)	20.6	1.3	18-23	22.3	2.7	19-30	18.3	1.5	16-22	20.8	2.1	18-25
2	100 (50)							19.3	1.5	16-23			
	100 (1)	21.8	1.7	18-25	21.2	1.5	18-24	21.0	1.2	18-24	18.6	1.1	16-21
3	20 (10)	21.6	2.0	18-24	22.8	2.3	19-27	19.2	2.1	16-23	19.2	1.6	15-23
	100 (1)	24.5	1.6	21-28	22.0	1.3	18-25	20.2	1.2	18-23	19.8	1.4	17-24
4	20 (10)	24.9	1.8	22-29	21.6	1.4	19-25	18.7	1.2	16-21	21.0	1.9	17-25
	100 (50)							19.4	1.6	17-24			
5	100 (1)	23.9	1.6	20-28	22.4	1.4	18-26	19.0	1.2	17-22	18.0	1.2	16-22
	20 (10)	24.0	1.4	21-27	22.1	1.9	17-26	19.2	2.7	14-24	18.8	1.9	16-22
6	500 (10)	23.4	1.7	19-27	23.5	1.5	20-28						
	100 (1)	22.2	1.4	19-27	22.9	1.5	19-27	17.5	1.1	15-20	20.7	1.3	17-24
7	20 (10)	23.3	1.8	21-28	23.2	2.4	19-27	17.2	2.1	14-21	19.3	2.3	15-23
	100 (50)							19.4	1.8	15-24			
8	100 (1)	24.1	1.2	22-26	23.0	1.6	19-27	17.5	1.1	16-21	19.4	1.8	16-23
	20 (10)	24.0	2.1	21-29	24.2	1.9	21-28	17.6	1.6	15-20	21.0	1.7	17-23
9	100 (1)	24.0	1.5	20-27	23.4	1.6	18-27	19.2	1.1	17-22	19.6	1.4	16-23
	20 (10)	23.6	1.7	21-27	23.4	2.1	19-27	17.8	2.0	14-22	19.9	1.8	16-23
10	100 (50)							19.4	1.2	17-23			
	100 (1)	23.9	1.4	20-27	20.7	1.4	18-24	19.2	1.2	17-22	18.8	1.4	16-23
11	20 (10)	22.8	1.7	20-26	21.7	2.2	18-28	17.8	1.2	15-20	18.2	1.9	15-23
	100 (1)	23.4	1.2	20-26	21.1	1.8	18-26	19.1	1.2	17-22	19.8	1.4	16-23
12	20 (10)	24.0	1.9	21-28	21.4	1.9	18-25	17.4	1.4	16-21	18.8	1.9	15-22
	100 (50)							19.3	1.2	17-22			
13	100 (1)	22.6	1.3	20-26	21.8	1.6	18-27	18.6	1.2	16-22	19.7	1.3	17-23
	20 (10)	22.6	1.4	20-25	21.4	2.4	16-26	17.5	1.8	15-21	17.8	1.5	15-21
14	500 (10)	22.1	1.4	19-27	21.7	1.9	18-27						
	100 (1)	21.6	1.5	18-25	23.5	1.8	20-29	18.9	1.2	16-23	19.2	2.1	15-24
15	20 (10)	22.2	1.9	18-26	23.4	2.8	19-30	17.4	1.7	15-21	19.9	2.3	16-25
	100 (50)							19.1	1.2	17-22			
16	100 (1)	22.5	1.2	20-25	21.4	1.4	18-24	18.6	1.2	16-21	18.4	1.5	15-22
	20 (10)	22.0	1.4	20-26	21.2	2.0	18-26	17.0	1.7	14-21	18.6	1.6	15-22

TABLE 1 (continued)

AGE	TYPE OF COUNT	M	S.D.	A.R.	M	S.D.	A.R.	M	S.D.	A.R.	M	S.D.	A.R.
13	100 (1) 20 (10) 100 (50)	21.8 22.0	1.3 1.6	19-25 19-25	24.2 23.0	1.4 1.5	21-27 19-25	18.8 17.1 19.1	1.2 1.2 1.2	16-21 15-20 17-22	20.8 19.9	1.4 2.0	18-24 16-24
14	100 (1) 20 (10)	22.4 23.3	1.4 1.9	20-26 20-27	22.0 19.9	1.3 1.5	18-26 17-23	19.4 18.6	1.2 1.8	17-22 16-22	18.6 19.9	1.3 1.2	17-22 18-22
B	100 (1) 20 (10)	19.9 18.5	1.5 1.6	16-23 16-22	21.5	1.8	18-27	21.4	1.5	17-25	20.9	1.3	18-24
1	100 (1) 20 (10)	21.5 21.4	1.2 1.9	19-24 16-24	20.9	1.5	17-24	20.5	1.4	18-24	19.3	1.2	17-22
2	100 (1) 20 (10)	22.4 21.8	1.2 1.5	19-25 19-25	22.0	1.6	18-27	20.8	1.2	18-23	21.4	1.5	18-26
3	100 (1) 20 (10)	21.4 23.5	1.0 2.0	19-24 20-28	22.6	1.5	20-27	20.7	1.3	19-24	24.4	1.6	21-28
4	100 (1) 20 (10) 500 (10)	21.4 22.5	1.2 2.7	19-26 18-29	20.7	1.3	18-23	21.4	1.1	19-24	21.5	1.4	18-25
5	100 (1) 20 (10)	21.4 21.8	1.3 1.9	18-24 17-25	21.8	1.3	19-26	21.1	1.3	19-25	23.2	2.1	19-30
6	100 (1) 20 (10)	25.3 23.7	1.6 3.1	22-31 19-30	21.5	1.3	19-25	20.8	.9	19-23	23.2	1.3	20-26
7	100 (1) 20 (10)	20.4 21.5	1.2 1.8	18-23 19-25	22.5	1.3	19-26	19.5	1.2	17-23	22.0	1.2	20-25
8	100 (1) 20 (10)	20.9 20.6	1.2 1.2	18-23 19-23	20.7	1.2	18-24	20.5	1.3	18-23	20.0	1.1	18-23
9	100 (1) 20 (10)	21.2 20.6	1.8 1.3	18-26 18-23	21.8	1.4	19-26	19.1	1.1	17-22	21.1	1.2	19-25
10	100 (1) 20 (10) 500 (10)	21.2 21.5	1.4 2.0	18-24 18-26	21.6	1.2	19-24	19.8	1.1	17-22	20.9	1.2	18-23
11	100 (1) 20 (10)	21.2 22.2	1.4 2.6	19-24 18-28				19.4	1.0	17-22	20.2	1.5	17-24
12	100 (1) 20 (10)	21.7 20.9	1.3 1.2	19-26 19-24	21.4	1.1	18-23	20.7	1.2	18-23	19.1	1.1	17-22
13	100 (1) 20 (10)	21.4 23.6	1.6 2.8	18-26 20-31	22.3	1.2	20-25	19.1	1.2	17-22	20.4	1.2	17-23

AGE	TYPE OF COUNT	M	S.D.	A.R.	M	S.D.	A.R.	M	S.D.	A.R.	M	S.D.	A.R.
14	100 (1) 20 (10)	20.6 20.3	1.4 1.5	17-24 19-24	22.7	1.4	20-26	20.1	1.2	17-23			
B	100 (1)	22.1	1.3	19-26									
1	100 (1)	19.0	1.3	16-22	20.8	1.3	18-23	20.7	1.4	17-25	26.5	1.6	24-30
2	100 (1)	18.9	1.4	15-22	21.0	1.5	18-25	19.6	1.4	16-24	23.1	1.4	20-28
3	100 (1)	19.2	1.1	17-22	21.1	1.5	17-24	17.1	1.3	14-21	21.9	1.4	19-26
4	100 (1)	19.2	1.3	16-23	21.9	1.2	19-24	18.5	1.4	15-23	21.1	1.2	19-25
	500 (10)							18.8	1.4	16-22	26.3	1.6	22-31
5	100 (1)	19.3	1.3	17-22	20.2	1.4	17-24	18.5	1.4	15-23	23.3	2.0	18-28
6	100 (1)	19.0	1.2	16-21	23.1	1.4	20-27	18.6	1.2	15-22	21.4	1.4	17-25
7	100 (1)	20.4	1.4	17-23	22.2	1.3	19-26	19.7	1.3	17-24	24.0	1.3	21-27
8	100 (1)	19.0	1.4	16-24	22.2	1.2	19-24	18.9	1.2	15-22	25.2	1.6	22-29
9	100 (1)	19.1	1.4	16-23	20.6	1.4	18-25	19.4	1.3	17-22	21.4	1.5	18-25
10	100 (1)	19.2	1.3	17-23	23.0	1.3	20-27	18.3	1.1	16-21	24.8	1.6	22-31
	500 (10)										24.4	1.5	22-29
11	100 (1)	19.0	1.2	17-22	19.2	1.4	16-23	17.6	1.3	15-21	23.8	1.7	19-29
12	100 (1)	19.1	1.4	16-22	19.5	1.4	17-24						
B	100 (1)	24.5	1.3	21-27									
1	100 (1)	22.0	1.5	19-25	19.6	1.3	17-23	19.0	1.2	16-22	23.5	1.2	21-26
2	100 (1)	23.9	1.3	20-28	18.6	1.5	16-23	21.4	1.2	19-25	21.8	1.2	19-24
3	100 (1)	22.9	1.6	20-27	20.9	1.4	17-24	19.0	1.0	16-21	22.0	1.4	19-25
4	100 (1)	23.7	1.5	20-27	19.3	1.4	16-23	20.8	1.3	18-24	21.4	1.2	19-24
	500 (10)				17.0	1.3	15-20	22.4	1.5	18-26	20.6	1.2	18-24
5	100 (1)	22.2	1.5	19-26				21.7	1.8	17-28			
6	100 (1)	24.6	1.5	21-28	18.6	1.2	16-22	19.6	1.3	17-22	22.3	1.2	20-25
7	100 (1)	25.9	1.5	21-28	19.3	1.6	16-23	19.6	1.1	18-23	20.1	1.3	18-23
8	100 (1)	19.3	1.5	15-22	18.3	1.2	15-21	21.6	1.0	19-24			
9	100 (1)	26.2	2.0	20-30	23.9	1.2	15-20	21.6	1.3	18-25			
	100 (1)					1.6	21-28	20.1	1.1	17-23			
10	100 (1)	25.9	1.7	22-30	19.0	1.5	16-23	23.1	1.2	21-26			
	500 (10)							20.6	1.4	17-25			

¹ 100 (1) indicates 100 counts on 1 hair.
 20 (10) indicates 2 counts on each of 10 hairs.
 100 (50) indicates 2 counts on each of 50 hairs.
 500 (10) indicates 50 counts on each of 10 hairs.

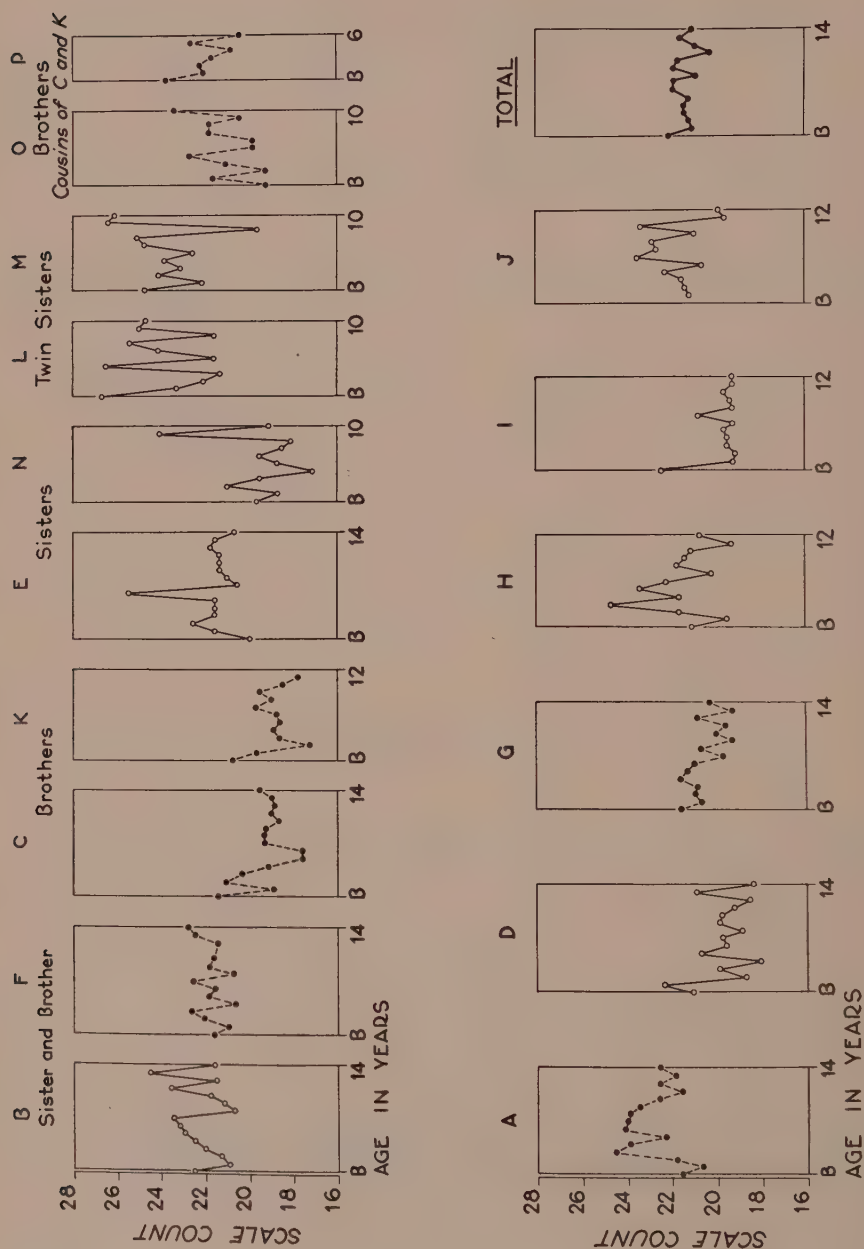


Fig. 2 Individual graphs and a composite graph of mean scale counts (100 counts on 1 hair from each sample) according to age for all 16 subjects.

through 10 years (table 3). The results corroborate the finding determined from the larger, incomplete matrix, that there is a highly significant difference in the mean scale count between individuals, but indicates no significant age difference through 10 years.

TABLE 2

Analysis of variance of ages and of individuals for the complete group (incomplete matrix) for scale counts according to the method of 100 counts on 1 hair from each sample

SOURCE OF VARIANCE	DEGREES OF FREEDOM	SUM OF SQUARES	MEAN SQUARE	F RATIO
Age	14	41.25	2.94	1.97* A/D
Individual	15	445.10	29.67	19.79** I/D
Discrepance	175	262.38	1.50	
Total	204	748.73		

In this and succeeding tables * indicates significance at the 5% level and ** significance at or below the 1% level.

TABLE 3

Analysis of variance of ages from birth through 10 years and of individuals A through O (complete matrix) for scale counts according to the method of 100 counts on 1 hair from each sample

SOURCE OF VARIANCE	DEGREES OF FREEDOM	SUM OF SQUARES	MEAN SQUARE	F RATIO
Age	10	26.23	2.62	1.52 A/D
Individual	14	384.02	27.43	15.91** I/D
Discrepance	140	241.40	1.72	
Total	164	651.65		

Method differences. An analysis of variance was made to determine the significance of differences between the means of 100 scale counts on 1 hair and the means of 2 scale counts on each of 10 hairs from the same sample. Five subjects, A through E, were tested using the mean scale count of 15 age levels, for the first month sample and for every 12-month sample through 14 years of age (table 4). The interaction between method and age is not significant. On the other hand,

there is a significant interaction between method and individual indicating that the two methods do not give equivalent results for all individuals. Re-examination of the data with this in mind indicates that the differential effect is due chiefly to subject C, who presents differences between the two methods which are significant throughout the age levels and who, therefore, is mainly responsible for the significant interaction found between age and individual for this small group. The F ratio for methods is not significant indicating that for these particular subjects the two sets of means give compatible results,

TABLE 4

Analysis of variance of ages (from birth through 14 years), of individuals (subjects A through E), and of methods of scale counts (100 counts on 1 hair and 2 counts on each of 10 hairs for each sample)

SOURCE OF VARIANCE	DEGREES OF FREEDOM	SUM OF SQUARES	MEAN SQUARE	F RATIO
Age	14	32.82	2.34	
Individual	4	389.31	97.33	
Method	1	1.22	1.22	2.86 M/A \times M \times I
A \times I	56	108.16	1.93	4.54** A \times I/A \times M \times I
A \times M	14	5.79	.41	
M \times I	4	10.14	2.54	5.96** M \times I/A \times M \times I
A \times M \times I	56	23.84	.42	
Total	149	571.29		

but because of the significant interaction between method and individual no statement can be made for individuals in general.

Another set of scale counts, made on hairs of subject C by taking two counts on each of 50 hairs for ages 1, 3, 5, 7, 9, 11 and 13 years were examined. In all the samples but one (5 year) the means of these counts are found to be much closer to the means of 100 counts on one hair from the same sample for each age period than are the means from two counts on 10 hairs.

Variability of scale counts. It was noted in examining the standard deviations of the distributions of two counts on each of 10 hairs that in most instances they were larger and

more varied than the standard deviations obtained from the series of 100 counts on a single hair. Scale counts consisting of 50 counts on each of 10 hairs from each 4- and 10-year sample for 5 subjects were studied in order to obtain further information on the variability of scale counts on the total population of hair. The 5 subjects are A, B, H, L and O and are unrelated. The two age periods, also, provide data for further comparisons of scale counts with regard to age.

From these scale counts an estimate of the standard deviation of counts on 1 hair, the standard deviation of the mean counts from hair to hair, and the total standard deviation of the population of hairs were obtained. These results and other pertinent data are summarized in table 5 and each column is numbered for ease of discussion. Column 5 shows the standard deviation of the total population of counts (50 on each of 10 hairs). This measure of total variability was separated into two components, that due to the variability of scale counts on a single hair (column 4), and that due to the variability of means from hair to hair (column 3). Comparison of columns 2 and 3 indicates that the standard error of the mean determined from 100 counts on 1 hair does not accurately predict the standard deviation of means actually obtained from samples of hair from the same population. Column 6 is the obtained mean $\pm 3.25 \times$ the standard error of the total population, the standard error having been obtained from the standard deviation of the total distribution of counts (column 5). Column 7 is the obtained mean $\pm 3.25 \times$ the standard deviation of means of counts on a single hair (column 3). The values shown in columns 6 and 7 indicate that the range of the true mean of the population of scale counts for a single individual at a given age can be determined more precisely from 50 counts on 10 hairs chosen at random than it can from counts on a single hair since the range of means from counts of the latter type is much larger and cannot be estimated from the standard deviation of the counts on one such hair. Column 8 may be compared with column 7. It shows the range of means of 100 counts on one hair from each sample for the entire age span.

TABLE 5

Statistical comparison of variabilities for scale counts on hairs of 5 subjects at ages 4 and 10 years

SUBJECT	AGE	MEAN 50 COUNTS ON EACH OF 10 HAIRS (1)	S.E. OF MEAN 100 COUNTS ON 1 HAIR (2)	S.D. OF MEANS OF 10 HAIRS 50 COUNTS ON EACH OF 10 HAIRS PER HAIR (3)	AVERAGE S.D. OF 50 COUNTS ON EACH OF 10 HAIRS (4)	S.D. OF POPULATION (5)	EXPECTED RANGE OF POPULATION MEANS		ACTUAL RANGE OF MEANS (8)
							50 counts on each of 10 hairs (6)	50 counts on 1 hair (7)	
A	4	23.41	.16	.93	1.41	1.69	22.40-24.42	20.39-26.43	20.68-24.47
	10	22.12	.13	.82	1.15	1.41	21.24-23.00	19.45-24.78	
B	4	23.54	.14	.40	1.42	1.51	23.12-23.96	22.20-24.88	20.71-24.24
	10	21.73	.16	1.14	1.46	1.86	20.49-22.97	18.03-25.43	
H	4	23.21	.14	1.58	1.34	2.07	21.49-24.93	18.07-28.35	19.07-24.38
	10	20.20	.12	.86	1.19	1.46	19.26-21.14	17.40-23.00	
L	4	23.29	.17	1.29	1.49	1.97	21.88-24.70	19.10-27.48	21.13-26.47
	10	23.83	.15	1.01	1.32	1.66	22.73-24.93	20.55-27.11	
O	4	21.71	.15	1.17	1.35	1.79	20.44-22.98	17.91-25.51	19.00-23.07
	10	20.64	.13	.73	1.22	1.42	19.85-21.43	18.27-23.01	

It may be noted that these ranges for the most part could have arisen as sampling variations of means of counts on a single hair.

DISCUSSION

The present investigation consists of 28,480 counts on a continuous series of 1,331 hairs taken from 16 White children from birth through 14 years of age (table 1). Five pairs of siblings, of which one pair is identical twins and two pairs are first cousins, are represented in the group. Tests were made to determine whether or not age differences are a significant factor in scale count and which of various combinations of hairs and counts give the most accurate value for the scale count of the entire population of hairs for an individual at any one age.

Gamble and Kirk ('41) found scale count to be an individualistic character of hair following an investigation which included 7,846 counts of several types on 3,267 hairs from 37 subjects at various age levels. Their statistical analysis stressed the mean and actual range of scale counts.

Due to the homogeneity of the group of children comprising the present study, it is suggested that the material affords a more critical test of the reliability of scale count than would be afforded by a group of individuals selected at random with regard to age and relationship. It may also be pointed out that a study of variance of scale counts provides an important addition to an analysis of the means and actual range of counts obtained by various sampling techniques since it yields an estimate of the reliability of these means. Such an estimate is particularly necessary in order to choose a method of sampling which can best provide a measure of individualization.

The method of making 100 counts on a single hair chosen at random from a given sample supported the thesis that there is a highly significant difference in scale count between individuals. This conclusion was reached for the present study by the analysis of the incomplete matrix (including all samples examined for all children whether they had reached 14 years of age or not) as well as by the analysis of the complete matrix

(including only those samples examined for children who had reached 10 years of age) (tables 2 and 3). The results from the incomplete matrix indicate a difference in ratio between age groups which is significant at the 5% level but the complete matrix presents results showing no significant age difference. Thus, it appears that with the possible exception of a low period at ages 11 and 12 (for which data are inconclusive) there is no evidence against the hypothesis that age up to 15 years is not a factor *per se* in the average number of scales on the hairs of children in this group. In other words, it is suggested that the average scale count is homogeneous for the individual regardless of his age.

However, whereas no general trend in scale count with age is evident, individuals do show differences from year to year, both in the mean numbers of scales and in the standard deviations. It is possible that these differences may be caused by various factors, some related to growth in general, and some being specific for the individual. On the other hand, these variations may be no greater than the variability of hairs on the vertex at any one age. This seems unlikely, judging from the estimate of variability of the mean as calculated from the standard deviation of 100 counts on one hair from each sample unless such standard deviations do not give a true estimate of the standard error of scale count means of different hairs at any one age.

In order to study degree of variation in scale count from hair to hair of a given individual at a specific time several different methods of counting scales were applied each of which involved more than one hair.

The first test compared the differences between mean counts of 100 on 1 hair and 2 on each of 10 hairs using samples from the first 5 subjects throughout the age period. This analysis of variance (table 4) indicates that the age trend, if any, is unaffected by the difference in method but that a significant interaction between method and individual, chiefly based on the data for subject C, does exist. Thus, whereas the variance due to these two methods alone is not significant, the fact re-

mains that a conclusion concerning individuals in general cannot be drawn.

Further counts (2 on each of 50 hairs) on the odd year samples of subject C provided means which are much closer to the means of 100 counts on one hair than are the means of two counts on 10 hairs from the corresponding sample (table 1). Since the means of the latter type counts (2 on 10) present larger and more varied standard deviations, as well, it would seem that the data derived from this method of scale count are too easily affected by rare values and are, therefore, somewhat unreliable. It should be noted that in no instance were the data adjusted by eliminating erratic single counts at extreme ends of the range or by any other method.

In order to check further the variance of scale counts on different hairs of the same vertex as compared to the variance on a single hair at a given time the data from 50 counts on each of 10 hairs were analyzed for 5 unrelated subjects. Two age periods (4 and 10 years) were included for further comparisons of age. The variation of the means from hair to hair is considerably greater than can be expected from the standard error of the mean when calculated from the standard deviation of 100 counts on one hair from the same sample (table 5). In other words, the population of scale counts, as evidenced from these samples of 50 hairs each, is not homogeneous from hair to hair, but actually varies considerably, and the true standard error of the mean cannot be obtained by utilizing counts from one hair. In terms of sampling this indicates that the scale counts on hairs of a given sample are heterogeneous and that a better estimate of the mean scale count can be obtained from one count on each of 50 hairs selected at random than can be obtained from 100 counts on any one hair.

These data support the earlier finding that there is no significant change in average scale count for the group as a whole due to age. The variability in average scale counts for the complete age range for these 5 subjects, based on 100 counts on one hair of each sample is for the most part no greater than the variability of means from hair to hair in one

sample at a given age. In other words, the variability from age to age is no greater than that which can arise from sampling alone. Likewise, the determinations made from two counts on each of 50 hairs (found to be the most reliable statistically) from samples of subject C further substantiate this conclusion, since for these samples the means are almost constant from age to age.

However, for subjects B and H, the means obtained from 50 counts on each of 10 hairs from the 4-year and 10-year samples do differ significantly from each other, thus, indicating that certain individuals show significant differences in scale count at different ages even though no general trend with age is ascertainable. It should also be noted that the standard deviations of the means of scale counts of the 10-year samples are greater than those for the 4-year samples in all of these 5 subjects excepting B. In the case of subject B, where the reverse trend exists, there is some question concerning the small value of the standard deviation obtained from the mean counts at 4 years since the total range of counts made on this sample (100 counts on 1 hair, 2 counts on each of 10 hairs) would indicate that the standard deviation might be expected to be larger than the one obtained. The total standard deviation of the means of scale counts of the 10-year samples of the other 4 subjects are all lower than those of the 4-year samples at the 1% level of significance according to determinations by the F ratio. This may be an indication that there is a tendency for hair to become more homogeneous in scale count as the child grows older, but there is no confirmation of this hypothesis from the standard deviations obtained from the data of two counts on each of 10 hairs. However, it would be well to take this possibility into account if extrapolation of these findings to adults is attempted.

The heterogeneity of samples of hair with regard to scale count indicates that it is not possible in most cases to identify a child by scale counts on one hair, since the range of means of counts on one hair shows almost as much variability as there is among individuals. Extreme cases might possibly be

identified by scale counts on one hair but actually it would require a random sampling of counts on many hairs to determine a mean which would be sufficiently reliable to be taken as a measure of the scale count for an individual. With this latter technique scale count is of definite value as an eliminative factor in individualization, since the evidence points to the fact that mean counts do vary from individual to individual.

SUMMARY

1. Series of scale counts have been made on head hairs from 16 White children from birth through 14 years of age. Four methods of counting were applied and the results are analyzed statistically.

2. An analysis of variance of mean scale counts indicates a significant individual difference but an insignificant age difference.

3. Two different methods of counting (100 counts on 1 hair and 2 counts on each of 10 hairs) when compared by an analysis of variance indicate a significant interaction between method and individual. In other words, the two methods do not give equivalent estimates of means for all individuals.

4. Further analyses of sampling techniques for estimating the mean number of scales in a given hair population indicate that random counts on many hairs give a more reliable estimate of the mean than many counts on one hair.

5. The variability of mean scale counts on hairs taken at various ages from the same individual is, in general, no greater than the variability of mean scale counts on hairs taken at a given age.

6. Certain evidence is suggestive of the hypothesis that the variability of scale counts may decrease with increase in age.

7. The reliability of scale count as an eliminative criterion in the individualization of hair is questionable where only one hairs is utilized. Individualization is possible on the basis of scale count, however, when sampling takes into account the heterogeneity of hairs.

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“PURPOSE” OF TASTING GENE.—A gene appears to exist which enables its possessor to taste a synthetic compound [PTC] not known to occur in nature. It is not too easy to understand how such a gene can exist, nor to guess what its function can be.

A possible explanation for this gene's existence appears to have been demonstrated in this laboratory. The substance *l*-5-vinyl-2-thio-oxazolidone, recently isolated and structurally defined, occurs widely in nature, particularly in turnips and cabbage . . . Ability to taste *l*-5-vinyl-2-thio-oxazolidone was found to parallel exactly that for PTC. There can be little doubt that the same gene controls ability to taste this naturally occurring substance.

In regard to the “purpose” of the tasting gene, it is known that thiourea, thiouracil, *l*-5-vinyl-2-thio-oxazolidone, and other substances of similar constitution act as antithyroid drugs. This seems to point to some connection between the tasting gene and thyroid function.—William C. Boyd. Taste reactions to antithyroid substances. *Science*, n. s. vol. 112, no. 2901, p. 153.

FINGERPRINTS IN ESKIMOS OF THE NORTHWEST TERRITORIES

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ONE FIGURE

Previous studies on fingerprints of Eskimos have been concerned with samples that are unfortunately small. This is emphasized by Cummins and Fabricius-Hansen ('46) in a paper on Eskimos of West Greenland, though in comprising 140 individuals this sample is larger than the earlier ones from St. Lawrence Island (Midlo and Cummins, '31) and Point Barrow (Cummins, '35), respectively 64 and 55 individuals. Abel's ('33) series of 68 East Greenland Eskimos is questionably representative, in view of the concentration of family groups and because of known racial admixture in this region. The present collection from the Canadian Northwest, 218 females and 234 males, is a significant addition to the material recorded for the Eskimo, not only in terms of size of the sample but particularly on account of its provision for sexual comparisons.

The series is composed at least chiefly of full-blood Eskimos, mainly from Baffin Island (Pond Inlet, Pangnirtung, Coutts Inlet, Scott Inlet, Lake Harbor) but with some individuals from Ellesmere Island (Craig Harbor) and the district of Keewatin (Eskimo Point). The prints were obtained through the cooperation of the authorities of the Royal Canadian Mounted Police, to whom I am gratefully indebted.

Frequencies of the fingerprint pattern types, analyzed according to standard procedures, are listed in table 1. They

show the differential digital and bimanual trends of distribution that characterize random samples of all populations.

The total frequencies of the principal pattern types are: arches, 3%; loops, 62%; whorls, 35%. The index of pattern intensity, which expresses the number of triradii per individual and thus reflects the distribution of pattern types, is 13.2 (as compared with 14.39 and 14.25 for the Point Barrow and St. Lawrence Island groups respectively).

TABLE 1

Absolute frequencies of fingerprint types. Females, 218; males, 234

DIGIT	SIDE	ARCHES		ULNAR LOOPS		RADIAL LOOPS		WHORLS	
		♀	♂	♂	♂	♀	♂	♀	♂
I	R	3	0	105	78	7	0	109	156
	L	6	0	181	104	4	0	107	130
II	R	15	11	133	110	10	32	60	81
	L	18	11	129	121	24	30	48	72
III	R	8	2	174	180	1	1	35	51
	L	11	3	160	173	1	1	46	57
IV	R	7	3	109	83	3	10	99	138
	L	6	4	109	102	3	3	101	125
V	R	7	5	183	160	0	5	27	64
	L	12	4	175	175	5	2	26	53
All digits	R	40	21	704	611	21	48	330	490
	L	53	22	754	675	37	36	328	437
	R+L	93	43	1458	1286	58	84	658	927

The dactylodiagram according to the method of Poll (fig. 1) is of the mongoloid type, and a close parallel to the one recorded for West Greenland Eskimos.

Genotype frequencies for epidermal thickness (table 2), with the sexes combined, are essentially identical with the values in the West Greenland series.

The sexual distinctions (table 1) conform to the trends commonly evident in population samples, whatever the race. In females, whorls are fewer (30.1%:39.6%) and, though both

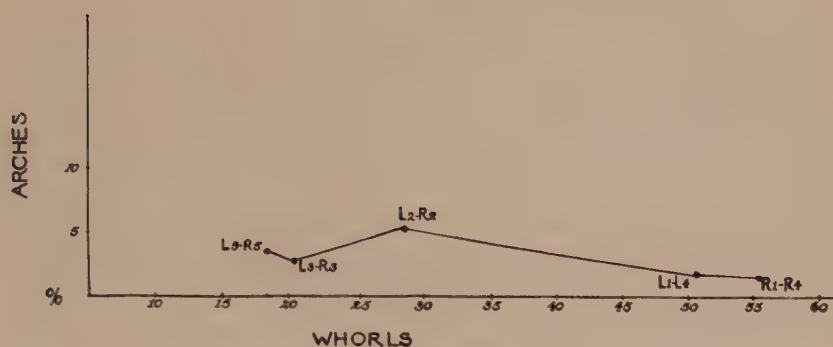


Fig. 1 Dactyliodigram (method of Poll), sexes combined.

TABLE 2

Genotype frequencies (see Bonnerie) of epidermal thickness (V), including comparison with Eskimos of West Greenland (Cummins and Hansen, '46)

	vv	vV	VV
	%	%	%
Northwest Territories			
♀ 217	60.0	31.3	8.7
♂ 235	74.0	22.1	3.8
♀ + ♂ 452	67.1	26.7	6.2
West Greenland			
♀ + ♂ 140	70.6	23.0	6.3

arches and loops are involved in compensatory increase of frequencies, the former patterns (4.2%:2.0%) are noteworthy. The arch/whorl index of Dankmeijer is 13.9 in females, 5.0 in males. Females follow the rule (Poll, '38) of all pairs and males follow the pair-group rule.

In evaluating the data here presented it should be emphasized that the samples representing the sexes are each larger than the number (200) set by Dankmeijer ('38) for statistical adequacy. At the same time, the parallelisms of findings in previous studies of Eskimos, where smaller samples were reported, are significant. It should be emphasized also that the geographic spread of this population is such that the factor of inbreeding is minimized.

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SEROLOGICAL RACE CLASSIFICATION.—The races which would result from . . . a classification [on the basis of blood groups] . . . would coincide only in part with the races of man as they have previously been delineated by anthropologists, and in some cases would appear even to be inconsistent with the known history of the people. The American Indian, for instance, known to be derived by direct descent largely, or at least partly, from Mongoloid ancestors emigrating from the Asiatic mainland, would have to be placed in a quite different race on the basis of blood groups . . . The very idea of racial differentiation implies that geographically isolated groups, although ultimately *of the same origin*, may eventually come to differ, and we have explained the mechanisms by which such differentiation can be brought about. Therefore, there is no reason why the Mongoloid appearance of many American Indians should in itself prevent our placing them in a racial category different from that of contemporary Asiatics. Aside from blood groups, we do not know what proportion of Mongoloid genes they really have, for we have not solved the problem of how many genes cooperate to produce the "Mongoloid" appearance.—William C. Boyd. Use of blood groups in human classification. *Science*, n. s. vol. 112, no. 2903, August 18, 1950, pp. 187-196.

BRIEF COMMUNICATIONS

NOTES ON THE PELVES OF THE FOSSIL APE-MEN

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THREE FIGURES

In South Africa we have been making important discoveries so fast recently that it is quite impossible to publish memoirs on them within a year or even two. We might withhold publication for many years as is so often done in the Northern Hemisphere, or we might issue preliminary descriptions and render ourselves liable to the criticism that our descriptions are inadequate. We think it much preferable to issue even inadequate descriptions and let other workers know something of our finds than to keep them secret for 10 years or more.

In a recently published memoir (Broom, Robinson and Schepers, '50) we gave figures and brief description of the almost perfect pelvis of *Plesianthropus*. This pelvis is one of the most important discoveries because we believe that it proves, almost certainly, that *Plesianthropus* was bipedal. In any case it proves that it was not at all nearly related to any of the living anthropoids—all of whose pelves are essentially different. All the known bones of any of what we have been calling ape-men are much more human than anthropoid. Though the brain capacity in one female is as low as 480 cm³, the teeth of the adult are all essentially human or nearly human in type.

Professor Dart has recently ('49a and b) given descriptions of a very fine ilium and much of an ischium of an adolescent of his Makapansgat ape-man which he calls *Australopithecus prometheus*. This is also a discovery of the greatest importance. Though we are not convinced by the evidence of his ape-man having made fire, we do think that he was more nearly human than the Sterkfontein being, and may thus perhaps have been able to make fire.

The Sterkfontein pelvis (*Plesianthropus transvaalensis*) is almost certainly that of a female. It is smaller than that of even a small

Bushman and though nearly human in structure it is manifestly not yet quite human. The ilium has the anterior part better developed than in man and more pointed. The sacral articulation is very definitely smaller than in man and forms relatively much less of the internal surface. It would thus appear that the iliacus muscle may have been better developed. Though there are a number of points in which the ilium differs from that in man, it is essentially human and very unlike the ilia of any known anthropoid or Old World monkey. In fact at first sight it is so human that one is apt to say that it is a human ilium. But when we look at the ischium we find that it is definitely not quite human.

In man, and apparently in all known types of man, there is a large irregularly rounded tuberosity to which are attached the semi-membranosus, biceps femoris and semitendinosus muscles. Over the whole tuberosity and its muscular attachments the large gluteus maximus muscle moves. In the Old World monkeys a callosity is present on the tuberosity and the hamstring muscles are attached in part to the sides of the callosity. In the gibbons there are well developed callosities as in the Old World monkeys. In the higher apes callosities occur in 36% of chimpanzees (Schultz) and indications of ischial pads are found occasionally in oranges and gorillas. In man there is never any trace of a callosity or specialised skin over the ischium. It would thus seem that in the ischial condition we might have some indications as to where the dividing line between ape and man lies. Unfortunately in fossil pelvises, often not perfect and slightly crushed, the evidence may not be altogether conclusive, but what there is seems to be of great value.

In *Plesianthropus* the ischium is satisfactorily known. The tuberosity is narrow and not rounded as in man, but much flatter, and situated farther from the acetabulum. The edges round the tuberosity are for the most part sharp and it seems fairly likely that the gluteus maximus muscle passed over it, and that while it had no callosity it may have had a pad somewhat like that of the chimpanzee. Clearly the condition is not unlike that in the large living anthropoids, and differs considerably from that in living man. It is to be regretted that hitherto no one has collected a pelvis of any of the fossil anthropoids.

Recently we were fortunate in discovering the os innominatum of a Swartkrans ape-man, *Paranthropus crassidens*, apparently a male.

The ilium and ischium and much of the pubis are satisfactorily preserved.

The ilium has its lower half almost perfectly preserved, and though much of the crest has apparently been eaten off a satisfactory restor-

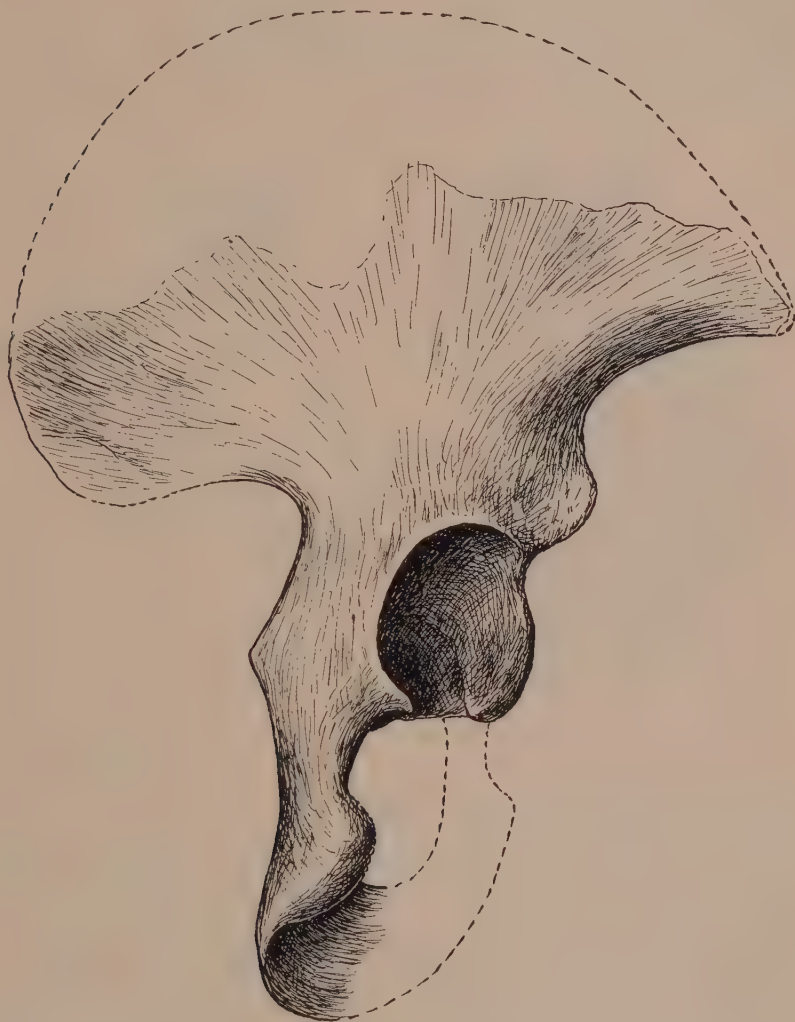


Fig. 1 Right os innominatum of Swartkrans ape-man, *Paranthropus crassidens* Broom. Probably male, $3/5$ natural size. Viewed at right angle to main plane of ilium.

ation can be made. The whole bone is a little crushed, especially in the acetabular region.

In the drawing given the ilium is viewed at right angles to its main plane for comparison with others. The ilium is very broad — 168 mm. The corresponding measurement in two male Bushman pelvis are 120 and 125 mm. The general shape of the ilium approximates to that of *Homo*, but there are numerous minor differences which will be discussed elsewhere. It will be manifest that there is little resemblance to the ilia of the anthropoid or Old World monkey pelvises.

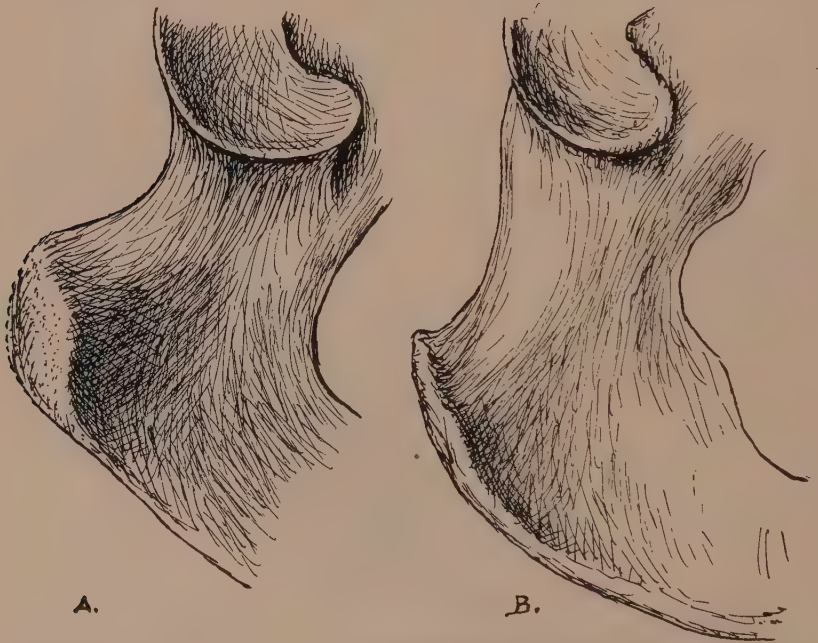


Fig. 2 Right ischium of (A) *Paranthropus crassidens* Broom, and (B) female orang. Both natural size.

The upper part of the pubis which is preserved does not differ greatly from that of man; but the ischium is seen to differ from that of *Homo* very markedly.

The whole ischium, except for a very small part at the lower end, is satisfactorily preserved. The acetabular portion differs little from that of man; but the part below the acetabular edge differs so greatly that no one would be inclined to regard it as human. The tuberosity is well developed. It is relatively narrow and very much shorter than in man. It is also remarkable in being rather a process which passes

first backwards and then outwards. While it has little resemblance to that of man it also differs very considerably from that of Plesianthropus. It is very differently shaped. There is no clear evidence of there having been a pad between the tuberosity and the skin. The upper part of the tuberosity is about 25 mm below the rim of the acetabulum. In Plesianthropus the distance from the acetabulum to the top of the tuberosity is about 20 mm and in the Bushman about 10 mm. If a drawing is made of the outer side of the ischium in a line at right angles to the main plane the remarkable difference will

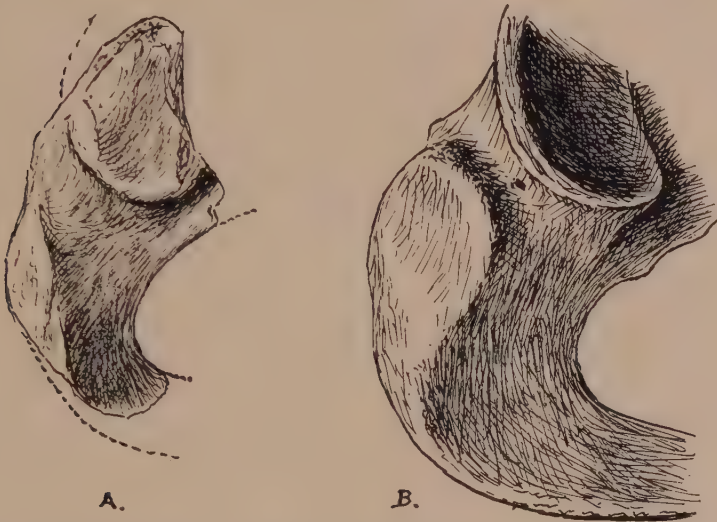


Fig. 3 Right ischium of (A) adolescent "*Australopithecus prometheus*" Dart, and (B) adult male Bushman. Both figures natural size.

be seen between this ischium and that of man. It will seem to resemble the anthropoid type more — but the resemblance is not close. It is a little like what we might suspect the baboon ischium to be if it had no callosity. Full illustrations of all the details of structure will be published elsewhere.

As only one specimen of the Taungs ape-man has been found, the type skull of the young child, and the cave where it was found was completely quarried away 25 years ago, we have no pelvis — and have little hope of getting one — of *Australopithecus africanus*. But we have much of another type of pelvis; that of the ape-man found in the Northern Transvaal near Pogietersrust. This being was described by Professor Dart about two years ago and named by him

Australopithecus prometheus. We differ from Dart in considering that this form should probably be placed in a different genus from the Taungs ape-man and we consider it a more human type.

A little over a year ago a very fine ilium of an adolescent was discovered and shortly afterwards the greater part of an ischium of probably the same individual. These were described by Dart ('49a and b). Unfortunately, though each bone is nearly perfect, one bone belongs to the right side, the other to the left.. It is difficult to make a fully satisfactory restoration in the absence of contacts.

The ilium is very like that of *Plesianthropus* and thus also very like that of man. The ischium resembles more that of man and differs considerably from that of *Plesianthropus*. As *Plesianthropus* has an ilium which is nearly human and an ischium which is more anthropoid, it seems not impossible that the Northern Transvaal form may have had an ape-man like ilium and ischium which is mainly human in structure. At present it seems probable that the ilium and ischium belonged to one individual.

We give drawings of the Makapansgat ischium and that of a Bushman made at right angles to the main plane of the bones. When these are examined it is seen that the tuberosity of the ape-man ischium is essentially like that of the Bushman. It is an irregular, rounded surface which probably gave attachment to the hamstringing muscles, with the gluteus maximus muscle probably moving over the top of all. The distance from the tuberosity to the glenoid is about 9 mm, thus closely resembling the Bushman condition and differing markedly from that in either *Plesianthropus* or *Paranthropus*.

The senior author recently ('50) argued in favour of the Sterkfontein, Swartkrans and Makapansgat ape-men being regarded as representatives of three distinct genera and considered that the Makapansgat type is the nearest to man and may have to be placed in the *Archanthropinae*. The structure of the pelvis seems to support this view.

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ON THE ZOOLOGICAL STATUS OF
TELANTHROPUS CAPENSIS

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Doctor Robert Broom and Mr. J. T. Robinson ('49) recently have briefly described a primate mandible for which they have created a new genus, *Telanthropus*. This specimen was found on April 29, 1949, in the cave at Swartkrans, South Africa, that has also provided remains of one of the Australopithecinae, *Paranthropus crassidens*. It came from a pocket that according to the authors "must be considerably younger" than the main deposit yielding *P. crassidens*—namely, "not improbably" Lower Pleistocene in contrast to possibly Upper Pliocene.

The authors conclude that their mandible is that of a "new type of man . . . somewhat allied to Heidelberg man, and intermediate between one of the ape-men [Australopithecinae] and true man." The baptismal name of this new specimen, *Telanthropus capensis*, fully indicates the phylogenetic implications, as does its being placed between the Australopithecinae and the *Pithecanthropus-Sinanthropus* group of men on the "primate family tree" in a subsequent paper by Broom ('49).

It is not my purpose to discuss the possible geological age of the mandible nor, indeed, to remark upon its morphological characters save for one point—namely, the relationship between the mylohyoid groove (which in life contains the mylohyoid nerve and vessels) and the mandibular or inferior dental foramen. This relationship was evidently a decisive factor in leading Broom and Robinson to regard their new specimen as belonging to a genus wholly distinct from *Paranthropus*. For they state: "The mylohyoid groove [of *Telanthropus*] runs up to the foramen as in typical human skulls. In *Paranthropus crassidens* the groove is, as in *Eoanthropus*, lower down . . . The typically human mylohyoid groove in our supposed man, and the certainly not typically human groove in *Paranthropus*, seem to make it certain that the two jaws belong to different genera."

The value of the form of the mylohyoid groove—and more particularly its relations to the mandibular foramen—as a reliable taxonomic character is open to serious question, however. It is true that it was considered to be diagnostic by both Keith ('25) and Frieder-

ichs ('32), but there is no evidence that either of these authors studied a sufficient number of specimens to enable them to appreciate fully the intrageneric variability to which the groove is subject. Keith regarded a groove that is separated from the foramen, lying "some distance" behind the latter, as the "anthropoid" or "simian" type, characteristic of adult anthropoid apes; this is the form of groove found in the Piltdown jaw ("Eoanthropus") and, according to Broom and Robinson, in *Paranthropus crassidens*. Similarly, Keith regarded a groove that is in direct continuity with the foramen as the "human" type, characteristic of man, although he recognized that it also occurs in gibbons and monkeys (but, apparently, he believed it to be only an unusual variant in all of the adult great apes); it is this type of groove that is described for *Telanthropus*.

On the basis of Keith's account, one might feel justified, as do Broom and Robinson, in regarding the presence of the "human" form of groove in *Telanthropus* as a diagnostic feature indicative of its human status. But, as will be shown, the occurrence of the "simian" type (as in *P. crassidens* and the Piltdown jaw) is possibly of greater taxonomic significance than the presence of the "human" type.

During the past few years I have been studying the form of the mylohyoid groove and its foraminal relationships in primates, including man. Altogether, over 500 mandibles have been investigated. I shall confine my present remarks to adult specimens, for there is evidence suggesting that there is a tendency for the groove-foramen relationship to undergo age changes in some genera. Only those data pertinent to the present problem will be given; it is expected to publish the complete study at a later date. The following data relate only to the so-called "human" and "simian" types; other categories (namely, complete absence of a groove, and the type intermediate between the "human" and "simian") are not considered here.

The so-called "human" type of mylohyoid groove (one that is in direct continuity with the mandibular foramen) is not uncommon among catarrhine primates and is the predominant type in certain genera besides *Homo* (among 54 men, chiefly U. S. Whites and Negroes, in 90%; 41 baboons, *Papio*, 74%; 80 gorillas, 72%; 44 gibbons, *Hylobates*, 45%; 13 Semnopithecinae, 35%; 78 orang-utans, 21%; 11 siamangs, *Symphalangus*, 18%; 10 guenons, *Cercopithecus*, 15%; 57 chimpanzees, 8%). Contrariwise, the so-called "simian" type (with no continuity but with wide separation of groove and foramen) is predominant only in the chimpanzee, although relatively common in some other forms (chimpanzees, 54%; orang-utans, 36%; guenons, 35%; gibbons, 23%; semnopithecines, 15%; gorillas, 9%;

baboons, 5% ; siamangs, 5% ; man, 0%). The very low frequency of the "simian" type in the gorilla clearly demonstrates that it is incorrect to assume (as did Keith) that this type is characteristic of *all* of the great apes. Furthermore, high frequency of one type does not preclude high frequency of the other type in the same genus, as witness the orang-utan and gibbon. Although bilateral symmetry in type of groove is the rule among catarrhines, asymmetry is by no means rare; thus the combination of "human" and "simian" types in the same mandible has been found in all 5 of the anthropoid apes.

Parenthetically, even if one adds to the "simian" or "anthropoid" type (as defined by Keith) the "intermediate" type of groove (which runs immediately adjacent to the dorsal margin of the foramen but is not continuous with the foramen itself), the conclusions are not altered fundamentally. The "simian" and "intermediate" types combined occur in only 10% of men, 23% of baboons, and 27% of gorillas; the frequency in the other groups under consideration ranges from 51% in gibbons to 85% in chimpanzees.

It will thus be seen that the "human" type of groove is the characteristic one not only in man but also in the gorilla and baboon, and anything but uncommon in the gibbon; it is rare only in the chimpanzee. Indeed, it appears probable that it occurs to some degree in all genera of extant catarrhines. Similarly, Keith's "simian" type prevails only in the chimpanzee, although it is quite common in the orang-utan and occurs to a less degree in other forms, save possibly man; I have not encountered it among the human material that I have studied (so that at best it must be of great rarity in man), and it is rare in the gorilla, siamang, and baboon.

Possibly the most characteristic hominid variant of the "human" type is more diagnostic. This subtype, in which the groove comes off the lower margin or apex of the foramen (rather than off its dorsal border), occurs in 85% of men, 74% of baboons, 38% of gibbons, 35% of gorillas, 21% of semnopithecines, 19% of guenons, 14% of siamangs, 4% of chimpanzees, and 2% of orang-utans. But even this fails as a truly distinctive human character, for it is almost as common in the baboon as in man and not at all uncommon in the gibbon and gorilla.

The above data demonstrate that the so-called "human" type of mylohyoid groove is highly characteristic not only of man but also of one great anthropoid ape and at least one Old-World monkey. Similarly, the so-called "anthropoid" or "simian" type is by no means characteristic of all the Old-World simians nor, indeed, of all the anthropoid apes or even all the great apes. The taxonomic

value of the groove-foramen relationship is thus highly limited, and its phylogenetic significance — if any — obscure. The occurrence of the “simian” type (as in *Paranthropus crassidens*) is possibly more suggestive of a simian status than is the presence of the “human” type (as in *Telanthropus*) of a human status; but even this is open to question. Certainly, to use the relationship of the mylohyoid groove to the mandibular foramen as an argument for the generic separation of *Telanthropus* from *Paranthropus*, or for the recognition of the former as a man, is unjustifiable. Broom and Robinson consider but dismiss the possibility that “this supposed human jaw might be an extreme variant of *Paranthropus crassidens*.” Whatever the other characters of the mandible and those of the teeth, there is nothing in the form of the mylohyoid groove to preclude this possibility.

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REVIEWS

MAN IN THE PRIMITIVE WORLD. AN INTRODUCTION TO ANTHROPOLOGY. By E. ADAMSON HOEBEL. McGraw-Hill, xii + 543 pp., 73 text figs. New York, 1949 (\$5.00).

Man in the Primitive World is a most attractively written general introduction to anthropology. The present review is restricted to the first 93 pages of the book in which the author deals with the materials which fall within the domain of physical anthropology. The book is intended largely for the college student.

Let me first say, then, that I much enjoyed reading the refreshingly written pages of Professor Hoebel's which are here under review. Professor Hoebel writes with balance and judgment, and even when he slips into error, our sympathy with him remains unshaken, for he is so clearly travelling in the right direction. Here are some of the points I noted.

On the origin of life only outdated references are given, while there is no reference to the recent works of Beutner, Oparin, and Jerome Alexander (p. 12). The geological table on p. 13 is not up to date. Although there may be some who could wish it true, it is *not* true to say that "Every bone that is present in each of the apes is also present in man (except the 13th rib)" (p. 15). Such statements as the following are, in my opinion, scientifically ridiculous. "Indeed . . . it seems as if most of the human body is formed of anatomical lags, many of which although they function (in contrast to the vestigial organs), do so with lamentable insufficiency" (p. 17). Is it not strange that this "lamentable insufficiency" should nevertheless permit Americans to live at least twice as long, on the average, as the longest lived non-human primate? It is incorrect to say that "the human embryo recapitulates the evolutionary history of the human race. This is known as the recapitulation theory" (p. 18). It is also incorrect to say that "it seems to be established that in a generalized way 'ontogeny repeats phylogeny,' or 'each individual climbs his family tree.' " This is not only far from established, but highly questionable. Professor G. R. De Beer who discusses this subject in his *Embryos and Ancestors* (Oxford), '39, laments the regularity with which these very statements recur in the examination papers of schoolboys.

The possible descent of man from monkey is categorically denied without any reference to the views of Straus (p. 21). The statement that "the apes have not evolved as far from the common ancestral forms as we have" (p. 21) is at least open to question. "Gibbonoid" (p. 24) suggests the possibility of "horseoid." Lower case initial letters in "parapithecus," "dryopithecus," "australopithecus," etc., (pp. 25, 26, 27) are happier in capital form, as required by the International Rules. "Humanoids" (p. 25) is an ugly word and suggests the possibility of "Manoids." The discussion of *Dryopithecus* is unsatisfactorily categoric, and the statements that the genus lived in "the period when the anthropoids of large bulk gave up tree life to come down to earth. Some of the forms grew larger brains and took to the habit of standing on their hind legs when they walked" (p. 25), will surely mislead the student. For some reason Professor Hoebel is under the impression that Leakey's finds were made in "Central Africa" (pp. 26, 36), instead of in East Africa. Dubois is spelled "Du Bois" (p. 27). The text correctly mentions the right half of the Piltdown jaw but figures it (fig. 11, p. 33) as the left half without mentioning that it has been reversed. The whole section on Piltdown (pp. 32-34) is out of date. A number of authorities did not "claim that the lower jaw was that of a giant gibbon" (p. 34). The chimpanzee has been most frequently mentioned. The Galley Hill and Clichy remains are not "really important finds" (p. 34). Galley Hill is postglacial and Professor Vallois informs me that the Clichy remains are almost certainly Neolithic at earliest. The statement that "The precise age of [the London] skull is mid-glacial (500,000 years)" (p. 35), is somewhat overdetermined. The fact is that we have no idea how old the London skull is. It may be post-glacial. The geological evidence is ambiguous. "*Homo kanamensis*" (p. 35) will not do, in spite of Leakey's original claim. Kanam man is a perfectly good example of *Homo sapiens*. Neanderthal man (spelled "Neandertal" throughout by Professor Hoebel) is described as a distinct species of the genus *Homo* (p. 36). Since Professor Hoebel nowhere defines what he understands by a species the student will not be much assisted. In any event, it might have been useful to mention the fact that many contemporary authorities regard Neandertal man as a subspecies or race of the species *Homo sapiens*. "Though quantitatively the equal of modern man in brain size, Neandertal man's mental equipment was not qualitatively up to the standard of ours. This judgment rests upon the fact that a smaller proportion of the brain volume and surface area occurs in the frontal lobes of Neandertal man than is the case with modern man" (p. 37, see also p. 87). Surely it is extremely doubtful whether a difference

in proportion of brain volume and surface area of the frontal lobes has anything whatever to do with the functioning of the mind. There is a mechanistic fallacy involved here which no anthropologist, dealing with this subject, should ever omit to analyze for his students. How often must it be reiterated that the form of the brain bears no relation to the quality of mental functioning in man?

The discussion of Cro-Magnon man is unsatisfactory. It hardly "remains to be determined" whether "Cro-Magnon man evolved by mutation from the Neandertal type, or by gradual development from the Piltdown-London prototypes of modern man" (p. 40). We can rule these possibilities out as almost certainly irrelevant. Such statements as the following are, I think, unfortunate in a text on anthropology. "Whatever his origin, Cro-Magnon man, at the height of the 4th glaciation, took over a large part of western Europe that had previously been under the control of the Neandertals" (p. 40). Apparently Professor Hoebel views the relations of prehistoric men as having been bellicose. Is "control" the right word? "Where Cro-Magnon man waxed, Neandertal man waned and disappeared. Here was struggle for survival on the great scale, truly affecting the destiny of all mankind for all human time to come" (p. 40). I wonder how Professor Hoebel knows? Is it not possible that Neanderthal and Cro-Magnon intermixed? The statement is made that the Grimaldi pair were Negroids and allowed to pass at that (p. 41). Eoliths and the Piltdown implement are accepted without question (pp. 43-46). "Chellean" is used (p. 46) rather than the preferred "Abbevillian."

The chapter on Races of Mankind is, on the whole, good, but here too, there are many errors. "Once a dominant trait not characteristic of the group as a whole is introduced into the population, the dominant phenotype will tend to spread, even though no new additions are made from the outside" (p. 74). A knowledge of population genetics would have been helpful here. Size of population and breeding structure make, of course, nonsense of such statements. It is not phenotypes which spread, but the genes partially responsible for their expression. Professor Hoebel skirts the whole subject of the genetics of racement as "vast" and "difficult," and dismisses it in a brief paragraph in which he says "that science does not know how new traits become established in the human genetic stream" (p. 75). This is incorrect. The general knowledge is available; its particular application is another matter. In terms of general principles it is today quite possible to convey to the student an accurate general idea of the mechanisms which have been involved in human evolution. The "Mongolian patch" is not "unique" to Mongoloid infants (p. 78). It has been found in some 90% of Negroes, and

occasionally occurs in Caucasoids (Larsen and Godfrey, "Sacral pigment spots," this Journal, 10:1927, 253-274). "Flat-arched" feet "with a prominently protruding 'larkspur' heel" are attributed to the Negro (p. 80), and a Mongoloid origin of the Bushman (pp. 80-81) is suggested. The first two statements are quite incorrect, and the last is a more than doubtful assumption. "Australia is the land of retarded zoological oddities. Australian man is a slightly retarded representative of *Homo sapiens*" (p. 81). The first statement prejudices the second, and the second is a non sequitur, in any event. Since the word "mongrelized" (p. 81) is generally used in the pejorative sense, its use in anthropology is contraindicated. The author's objectivity occasionally deserts him, as when he applies his own standards to the judgment of human beauty (p. 81). The author states that "There is little doubt that Negro perspiration has a different odor from that of Caucasian" (p. 87). But when we look for evidence all that is offered is conjecture and speculation. It is stated as "the opinion of anthropologists that all races except, perhaps, the Australian aborigines are equally capable of cultural development" (p. 91). The facts about the mentality of the Australian aborigines as I know them would certainly render it unnecessary to except them from this judgment.

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STERKFONTEIN APE-MAN PLESIANTHROPUS. By ROBERT
BROOM, J. T. ROBINSON AND G. W. H. SCHEPERS. Transvaal
Museum Memoir No. 4. 104 pp., 8 plates, 27 + 7 figs. Pretoria,
1950.

The stupendous discoveries of Dr. Broom and Professor Dart in South Africa continually increase in number and evolutionary importance. They constitute the only known material representing higher primate evolution just at the critical point of man's emergence from the anthropoid apes. The reviewer yields to no one in his admiration and respect for Professor Dart, but the present volume is by Broom and colleagues and, therefore, it is of Broom that I wish to speak briefly before summarizing the work.

The man is a phenomenon of scientific prescience, a genius in the exploratory sense, an incomparably energetic worker and possessed of an uniquely rich personality. He dumbfounds me with his accomplishments and also with his unfailing generosity in communi-

eating his magnificent finds by personal letter practically as soon as they come out of the rock and publishing them with a minimum of delay. The history of human evolution will always be associated with the name of Robert Broom.

The present volume describes the finds of 1947, 1948, notably the new *Plesianthropus* skull material, the dentition, a nearly complete mandible, parts of a scapula and humerus, pelvis and femur. A second part by Dr. G. W. H. Schepers deals with the brain casts of the newly discovered *Plesianthropus* specimens.

Here are a few high points and basic facts from the volume:

1. In the complete skull of the female *Plesianthropus* the triangular nasal bones are united and flat.
2. The maxillo-malar region is rather flat and the malar breaks sharply back to the zygomatic arch, as in the orang.
3. The premaxillary region is flat and separated from the lateral parts of the maxillae by swelling of the canine root sockets.
4. The zygomatic arch is huge and human in confirmation.
5. The capacity of the adult female skull (no. 5) is about 482 cm³—far above that of the female chimpanzee.
6. The occipital torus is so low as to leave about half of the squama uncovered.
7. The articular eminence is large; there is a large postglenoid process with a peculiar secondary process behind it. There is a small mastoid process.
8. "The palate is almost typically human."
9. The lachromo-ethmoidal articulation is large as in man and the orang.
10. In two specimens of *Plesianthropus* and one of *Paranthropus* the auditory meatus is much lower, the occipital condyle further forward, and the articular eminence better developed than in anthropoid apes.
11. *Plesianthropus* presents a sloping symphysis with a slight suggestion of an incipient chin. There is neither a simian shelf nor a pit. The mandible does not resemble that of *Proconsul* or those of contemporary anthropoids, but rather those of fossil men.
12. The dentition of *Plesianthropus* is now represented by about 135 teeth including deciduous and permanent sets. Broom concludes that the australopithecoid dentition, which in general agrees with that of man, has been derived from a pre-anthropoid precursor.
13. The scapula in general structure "is about intermediate between that of the Orang and that of man."
14. The humerus (head and greater part of shaft preserved) is typically human in shape of head, but shows some puzzling features in the form of the tuberosities. It appears to have been somewhat longer than the usual humeral length of male chimpanzees, but shorter than the humeri of large human males.

15. The pelvis is nearly complete. It is generally human in form, but differs from that of man in that: (a) the ilium has the anterior superior spine developed "more forwards," and the anterior superior spine continued on to the acetabular surface; (b) the tuberosity of the ischium is farther removed from the acetabulum than that of man, and the obturator foramen extends more downwards. The iliac crest is "directed as in anthropoids, mainly outward." The ischium and pubis in relation to main plane of the upper part of the ilium are twisted inward as in the chimpanzee and not outward as in man.
16. The upper two-thirds of a left femur suggests some differences in form of the trochanter from that usual in the Bushman.
17. The section by Dr. Schepers on the brain casts of the recently discovered Plesianthropus skulls includes tables dealing with comparative brain values, other dimensions, indices, and proportions. The author concludes that the australopithecids possessed brains significantly larger than those of anthropoid apes and definitely fashioned on "human lines." "As there are neural and collateral indications these creatures walked erect, had achieved a measure of manual dexterity of the human type, and might have been capable of an organized system of vocal expression and thus of social organization and communal life, they are clearly better defined as Pre-hominids or Proto-hominids."

The reviewer is not vastly interested in the semantic problem as to whether these South African fossil creatures should be called ape-men, men-apes, pre-hominids, or what will you. Whatever new discoveries are brought to light however detailed and lengthy studies may alter future conclusions on the morphology of these australopithecids, this priceless treasure of material illustrating the transition from fossil apes to fossil men should survive to attest and amplify the theory of human evolution.

Rather than discuss details of this work, I should like to finish this review by stating what I think ought to be done to exploit further this mine of fossil primate material.

1. Some person or foundation should provide excavation and publication funds for Broom and Dart to the amount of something like \$10,000 per year for the next 5 years.
2. Funds should also be provided for several research fellows in geology, paleontology, and anthropology, to help in excavations and in the working up of the material.
3. A first-class anatomical artist should be secured on full time to relieve Dr. Broom and his colleagues of the necessity of preparing their own line drawings and other illustrations.
4. It is my opinion that no American institution should intrude itself into this particular area for purposes of independent explorations, but perhaps some young American anthropologists might be

permitted to work under Broom and Dart. The United States should play its usual role of financial assistance (but without occupation). Here we can be assured that the money will not be wasted. The scientific dividends will be huge.

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PRINCIPLES OF HUMAN GENETICS. By CURT STERN. W. H. Freeman and Co., San Francisco. xi + 617 pp. 1949, (\$7.50).

The need for a textbook on human genetics has been felt about equally keenly by anthropologists, medical men, and by geneticists themselves. Such a text was slow in coming, because it is a more responsible undertaking to write the first book on any subject than to improve on the existing models. It is fortunate, then, that Curt Stern, one of the most effective teachers of genetics in our generation, has written an outline of human genetics which will doubtless remain the standard for some time to come. Stern possesses an almost uncanny ability to present even highly abstruse matters in readily understandable form. This ability has served him well in writing this book, and especially the chapters dealing with quantitative aspects of human population genetics. A didactically effective presentation of the kind found in this book connotes not merely a thorough knowledge of the subject, but also a clarity of thought which is met with not too frequently even among eminent scientists.

The mechanisms of heredity are among the most universal of all known biological mechanisms. Therefore, human genetics is basically like that of any other organism — mice, *Drosophila* flies, corn plants, and even fungi and bacteria. Any book on general genetics is, in a sense, a book on human genetics. On the other hand, "human genetics" is sometimes understood to mean a compendium of information on dominance or recessiveness of sundry human diseases and abnormalities. Stern's book belongs to neither extreme. The fundamentals of genetics are treated so thoroughly in the book that anyone who masters its contents may consider himself familiar with the main principles of the modern science of heredity. And yet, the attention of the reader is concentrated throughout on human problems. This is not only because human examples are used whenever convenient to illustrate the operation of genetic mechanisms. To use Aristotle's dictum, "man is a political animal," and this makes the evolutionary

pattern of mankind unlike that of any other species, even though this pattern involves only a peculiar constellation of mutation, gene recombination, selection, and genetic drift, in other words of the same agencies which are operative in other biological species. Moreover, since no crosses deliberately planned for experimental purposes can be arranged in man, numerous special methods of investigation have been developed for the study of genetical phenomena in the human species. These special methods are masterfully presented in the book under review. The old cliché, that man is a hopelessly unfavorable material for genetic investigation, can hardly survive an acquaintance with these methods. Many types of information available only for man make him uniquely advantageous for some types of genetic studies.

Among the 27 chapters into which the book is divided, anthropologists will be especially interested in the last 5, namely, "Heredity and Environment," "Selection and Eugenics," "Genetic Aspects of Race," "Genetic Aspects of Race Mixture," and "The Origin of Human Diversity." In these chapters Stern tackles problems which, because of their sociological and political implications, are highly controversial and apt to evoke passion. In his discussion of these problems Stern does perhaps as well as can be done, given the incomplete, contradictory, and often uncritically collected data with which the literature is replete. Stern's treatment of these issues has already evoked some partisan protest, and, in the opinion of this reviewer, future research is apt to vary some of his conclusions, although his general conclusions will probably stand. Stern is not an extreme hereditarian, and he is certainly too competent a geneticist to be tempted by any facile eugenical schemes. Nevertheless, he puts perhaps more weight on the data, which are supposed to demonstrate genotypic determination of the normal differences in intelligence and in emotional characteristics, than the present reviewer would be inclined to do.

It is difficult to deny that the available data indicate the existence of some genetic variance in mental traits among individuals belonging to the same social stratum and living in more or less similar circumstances. But this reviewer is not convinced that the average differences between the I.Q.'s observed between people of different classes and occupational levels also involve an appreciable genotypic component. Similarly, there is no denying the differential birthrates of people of different socioeconomic levels in some of the modern industrial societies. We know, however, less than we should about the extent to which these differential birthrates may be offset by differential mortality. After all, the chances of survival and of

normal development are lower for a child in a family with an annual income of under \$1000 than for a baby born in a well-to-do family. A child of a college-educated mother is probably better protected on the average than that of a feeble-minded mother. The bugaboo raised by some eugenists, that the differential birthrates of the social strata in modern society lead to disastrous lowering of the average intelligence level in the population as a whole, is, to say the least not as inescapable as it is alleged to be. Stern cannot be accused of any scare mongering in this connection, but he does spend more pages discussing the topic than it deserves in the opinion of this reviewer.

Stern defines race as "A genetically more or less isolated division of mankind possessing a corporate genic content which differs from that of all other similar isolates." This is in effect a paraphrase of the definition suggested by this reviewer, namely: "Races are populations of a species which differ in the incidence of one or more variable genes or chromosome structures." The mention of isolation in the definition of race may be misunderstood as implying some reproductive isolation, which characterizes species rather than races. The isolation meant is, of course, geographical and (in man) social and cultural, rather than reproductive. This is, however, implicit in the term "population," as used in modern population genetics. The term "isolate," applied, as far as this reviewer is aware, only in connection with man, is, of course, synonymous with "population."

Either definition makes almost any two human populations racially distinct, which comes as something of a shock to anthropologists who are led to suspect their genetical colleagues of a tendency towards undue splitting of races. This is, of course, a misapprehension as Stern quite explicitly shows. One should distinguish nomenclatorial and analytical problems in raciology. From the standpoint of the latter, it is not only legitimate but necessary to emphasize that the differences between populations of neighboring mountain valleys, or even of neighboring villages, are qualitatively of the same kind as those between the so-called, "major" races. But it certainly does not follow that one should invent hundreds of thousands of new racial labels. Race differences between human populations vary continuously from very small to fairly large, but at just what level they may deserve nomenclatorial recognition is a matter of expediency and nothing else. Realization of this makes the fact that no general agreement has been reached in anthropology concerning the number and delimitation of human races much less discouraging than it appears otherwise.

It may be worthwhile to point out in this connection that absolute genetic differences are not known to exist between any of the human races. To be sure, every individual in populations indigenous to Central Africa differs from any individual indigenous to Europe in skin color, hair form, shape of the nose, etc. All these differences involve, however, highly polygenic traits (the old hypothesis of Davenport, according to which the difference in skin color between Negroes and whites is due in the main to just two genes is almost certainly an oversimplification). It is, then, not only possible but probable that some of the genes characteristic of African populations occur scattered in European populations, and vice versa. Even if the frequencies of some genes do reach unity in some and zero in other human populations, it would not be very meaningful to set up two categories of racial distinction. Indeed, human populations differ, in at least a majority of cases, in the incidence of many variable genes, some of which may have diverged more than others.

The publication of Stern's magistral book signifies the coming of age of human genetics. This does not, however, mean the appearance of one more discipline ready to withdraw into its own shell of specialized terminology and research techniques. On the contrary, human genetics should be a link tying together sciences which for years were too separate for their own good: anthropology, genetics, and medicine.

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THIS IS RACE. AN ANTHOLOGY SELECTED FROM THE
INTERNATIONAL LITERATURE ON THE RACES OF MAN.

Selected, edited and with an Introduction by Earl W. Count.
Henry Schuman, New York, xxix + 747 pp., 1950 (\$7.50).

It is obvious that discussing individually the 60 pieces which form this unique anthology would mean discussing the whole history of physical anthropology and all the problems that have beset it from its inception to the present day, racial studies having always been its backbone. Our goal in this review has to be a far more modest one,

that is to give a glimpse of the great richness of this book to the prospective reader. Every person interested in physical anthropology should be a prospective reader, as I cannot think of any other book that gives an equally forceful insight into the accomplishments and shortcomings of physical anthropology as a whole.

Dr. Count has arranged his material in a purely chronological fashion, probably the safest procedure under given circumstances. He has subordinated the choice of the material to the underlying theme, meaning that sometimes an author is represented by a piece which is not the most brilliant one he has produced, but which is most relevant for contemporary attitudes towards the race problem.

A first division (The Eighteenth Century to the fall of Napoleon) contains the classic studies of Buffon, Kant, Blumenbach, Lamarck and Cuvier. We are struck by the fact how much was sometimes known about exotic populations at that time, how deeply a Blumenbach or Kant understood the basic problems, how much misinformation on the other hand still prevailed, how all-powerful seemed the influence of climate, and how little the biological notion of race had yet emerged from a cluster of physical, psychological, and linguistic data. The second division of the anthology, "The Earlier Nineteenth Century to Darwin," contains pieces by William Lawrence, Prichard, Broca, Retzius, Meigs, and Waitz, the monogenesis vs. polygenesis debate providing the most controversial issue of this period. In the third division "From Darwin to the First World War," we find Darwin, his main prophets Huxley and Haeckel, as well as the "sceptics" of transformism, like Quatrefages and Virchow. Topinard's discussion of the race concept is still as striking as it was 60 years ago. The great classifiers of this period are represented by excerpts from Beddoe, Ripley, Deniker and Haddon; the geographically-oriented by Fritsch, Stratz, and Giuffrida-Ruggeri. It also contains Sergi's stimulating Mediterranean hypothesis, and the classic contributions of Franz Boas (on descendants of immigrants) and Eugen Fischer (race as a domestication phenomenon).

Up to this point the selections are such that, except perhaps for the piece of Biasutti, this reviewer would not like to miss a single one. Things are a little different when we reach the last division, "The Twentieth Century since the First World War." Contributions like those of Dixon, Hrdlicka, Bean, Bolk, Keith, Morant, Eickstedt, and even of Coon, Imbelloni, or Czekanowski had, of course, to be incorporated, because they are representative for the period, whatever their validity might be in the long run. But I am inclined to think that one of the three geographers or one of the two blood-group men reprinted would have been sufficient to represent their

respective approaches in this division. I also feel that pieces like those of Bryn and Stolyhwo and perhaps a few others might have been expendable, and that the volume might have gained through such amputations. In this division especially, the variety of approaches must sometimes be somewhat bewildering to those not hardened through long acquaintance with the field. A most valuable feature in this respect are the fine historico-analytical pieces in this division by Scheidt, Bunak, and Jankowsky, which help greatly in understanding other selections. In this division the contributions of Hooton, H. L. Shapiro, Seltzer, Howells and Cheboksarow are particularly striking through their clarity and soundness.

My minor disagreements with Dr. Count concerning some of his selections can, of course, in no way diminish my enthusiasm for his selecting abilities as a whole, for the unique book he has created, and the tremendous amount of work he has carried through in creating this book. It is good that he has called this book an anthology so that nobody can confuse it with some of the so-called "source books" which often reproduce so few and such short selections that they never give to the student more than the delusion of information. Unlike these source books, Dr. Count provides selections sufficiently numerous and lengthy to give a true picture of the ideas they are intended to illustrate. Dr. Count's unusual linguistic talents have made it possible to give a well rounded international picture of raciology. Where no adequate translations did exist, Dr. Count has undertaken the task himself. The book contains no less than 18 translations by Dr. Count from the German, French, Italian, Norwegian, and Russian. It is obvious how valuable and stimulating such translating is in a discipline which in every country is cultivated only by a relatively small and isolated community of scholars who tend to be increasingly unfamiliar with foreign languages. In addition to the work of selecting and translating, Dr. Count has contributed an excellent analytical introduction to his anthology and a bio-bibliographical note to each selection.

Dr. Count's book is not meant primarily to be a historical book nor is it primarily one. It is a book on the still controversial problems of the origin and classification of races. It must, on the other hand, be stated that this anthology is at the same time of the highest value to the historian of science or anthropology. It is actually the most outstanding contribution to the history of physical anthropology made so far.

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RACES. A STUDY OF THE PROBLEMS OF RACE FORMATION IN MAN. By CARLETON S. COON, STANLEY M. GARN AND JOSEPH B. BIRDSELL. Charles C Thomas, Springfield, (American Lecture Series no. 77. A monograph in American Lectures in Physical Anthropology, eds. T. D. Stewart, A. H. Schultz, and W. W. Howells), xiv + 153 pp. 1950 (\$3.00).

Books on race usually elaborate a static morphological map of variation in a few external characteristics, or else they plaster the race concept so thickly with criticisms that the focus on biological variation itself vanishes. But Dr. Coon and his co-authors have done something quite new. Their Lecture is a series of instructive examples of the ways in which human variation in external and internal structure can relate physiologically and genetically to the huge range of habitable environments and to man's behaviour as a social animal. But this is more than a speculative exercise on our almost unknown powers of adaptation. It is a serious attempt to put together known data on such factors as surface-mass relationships, caloric intake, bone structure, genes, enzymes, pigmentation, population size, incest regulation, tuberculosis incidence, and dysenteries and low-protein diets of early urban peoples and to place each factor in the man-environment equation. This new approach aims to dissect the dynamics of race. Perhaps, in a crowded Lecture, it tends to over-dissect, though the tremendous gaps in our knowledge of physiological variation are indicated fully. But this is the approach of the future.

A chapter on genetics and the rôles of isolation and selection in race change precedes an outline of body build adaptations useful in each extreme of climate. Presumptive adaptations of surface tissues to light and heat excesses and to cold and cloudy extremes complete the background for sketches of human evolution and of civilization and disease, and for a taxonomy of races.

The most novel material is that interpreting mongoloid specializations of body mass, facial skeleton, integument, and fat placement, nasal air-heater, and slow-growing beard as responses to extreme cold. Equally interesting is the discussion of the surface-mass ratio in relation to climate: climatic selection of lanky or massive individuals seems to underlie many racial peculiarities in body build. And the results of the need for a reduction in heat-radiating skin surface in cold climates and the consequent raised frequency of stocky physiques and of obesity (useful also in a band of starving hunters) are of special interest to our own overfed and well-warmed population, with its largely "glacial" ancestry. But very little can be written about the growth-control mechanisms which produce this and other important

variations in body form, size, or skin protectiveness. The authors' stress on direct effects via soil minerals, protein-poor diet, or early adrenarche in cold climates are well worth following up. Here they could profitably have described the phenomena of relative growth (heterogony) in relation to epiphyseal closure sequence. This growth mechanism allows a single modifying force, environmental or genetic, to produce many superficially separate changes in adult structure. On the other hand, the incredibly quick plastic responsiveness of the skeleton and its importance in evolutionary and race history studies are mentioned. And the necessary distinctions are clearly drawn between such mechanisms of racial change as genetic drift, individual adaptation to the environment, the many possible selective forces, and hybridization. The clarity of distinction between stocks, races, and types is less sure. But the concrete categories chosen seem unseable ones, especially with their stress on emerging blends like Neo-Hawaiian.

Nevertheless, the chapter on "Race and the genes" is oversimplified even for a general Lecture: the fact that genes are potential and interdependent (not inevitable and specific) initiating forces is mentioned so casually that such phenomena as pleiotropism, suppression, linkage, and multiple factor effects are overlooked. Even random assortment and recombination are unmentioned as factors maintaining or, through hybridization, increasing the variability necessary for race formation by selection or the other forces discussed. Though the need for proper diet is stressed, genetic and environmental controls of growth rates and timing, heterogony, and endocrine secretions and tissue specificities are omitted. This gap later on prevents thorough analysis of the racial dynamics of body build and climate, skull form, etc. The authors set out to be cautious in the area of behaviour differences, but then write: "the capacity for leadership, like the capacity to be led, may well be based on certain fundamental physiological rhythms, which could be inherited." To a hasty reader, ignorant of the work of psychologists showing the overwhelming determining power of education in group studies or even between identical twins (where underlying genetic factors can be hazily identified), this quoted passage might seem nonsense.

These and a few other lapses all result from abbreviating to suit the public's taste, and could be changed without too great complexity. They seem inevitable in a pioneer work and irrelevant compared to the book's stimulating emphasis and its range of facts on physiologi-

cal variation. This Lecture consistently asks the most fruitful questions and then shows where the answers will be found.

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EARLY MAN IN THE NEW WORLD. By KENNETH MACGOWAN.
The Macmillan Co., New York, xv + 260 pp., 1950 (\$5.00).

Few subjects of such popular interest as that stated in the title of this book are so limited in factual background. Man came to the New World in relatively late times, successfully hid his dead and left little in the way of cultural evidence at the places where he lived. Even as his descendants multiplied they were usually isolated, band from band, in this vast and rich new country. Rarely did they find that their camp sites had been occupied previously and they were under little compulsion to take refuge in caves. Thus here, unlike the old World, archaeologists have had a difficult job of piecing together a record, originally limited and often fragmentarily revealed.

It is true that a considerable literature has developed about this subject. A large part of this literature, however, is a rehashing of facts and ideas. The facts themselves have remained pretty scanty. In recognition of this situation some writers have distinguished between "early man" in the New World and "ancient man" in the Old World. Except in the New World, "early man" has been largely overshadowed by the better documented "ancient man."

Prof. Macgowan has performed quite a feat, therefore, in writing a book under the title of "Early Man in the New World." Of necessity he has done this by writing extensively about "ancient man," under the guise of introducing readers to "early man." But also he has done this by writing about "not so early man": about diffusion vs. independent invention in determining the higher Indian cultures, and about the Indian's agricultural achievements.

Few general readers will object to Prof. Macgowan's gentle deception. Most will want to learn more about these related subjects anyway, and they will be easily beguiled by the writer's lively style, aided by Campbell Grant's imaginative illustrations. At times, indeed, a fine perspective of man's development is achieved (see for example the middle paragraph on page 6).

Nevertheless, when he comes at last to discussing the few available facts about the skeletal remains of early American man, it is unfortunate that Prof. Macgowan has neglected these facts for certain dramatic interpretations of opinions. Obviously, here he has been led astray in the main by Gladwin's "Men out of Asia" (same illustrator, same dust-jacket praiser!). The uncritical judgments in the field of physical anthropology of these authors are combined to provide the reader with a fantastic picture of the appearance of early man.

The argument goes like this: Because some of the recent Mongolian peoples of Asia are round-headed, the putatively early elongated "craniums" from America are not Mongoloid. Then what are they? Well, since some observers have subjectively typed these skulls, together with the skulls of recent Indians, as Melanesoids, Australoids, Negroids, etc., therefore the first men to reach the New World were distinct racially from the later Mongoloid Indians. Moreover, although these views are admitted to be heretical, they are recommended for the reader's serious consideration on the grounds that all students of the subject who think otherwise are biased.

Perhaps Prof. Macgowan has his tongue in his cheek while reporting this sort of logic, but if so, the reader cannot detect it. However, most physical anthropologists should be able to detect a weakness of critical evaluation in the way some of the facts about the early skeletal remains are reported. Examples: The Lagoa Santa skulls from Brazil are described as having "the heavy brow ridges and the long narrow shape of the Australoid — and the Neanderthal —" (p. 98). The Punin and Paltocalo skulls from Ecuador (the latter found in association with recent cultural objects and selected for their resemblance to the Lagoa Santa type) "seem much more archaic than any of those found in Brazil" (p. 101). ". . . if evidence dug up at Melbourne in 1925 means anything, it means that a mammoth or a mastodon stepped on the skull of some variety of early man and left it flat as a pancake" (p. 102). ". . . Stewart . . . showed . . . that the Melbourne man had the long, narrow, flat-sided head, the low forehead, and the strong brow ridges typical of most craniums found under conditions that suggest antiquity" (p. 103). ". . . most early craniums have three features that are lacking in the Eskimo — jutting jaws, slanting foreheads, and heavy brow ridges — all stigmata of the Australo-Melanesian" (p. 212).

Distortions such as these, reflecting an unfamiliarity with the science of physical anthropology, spoil an otherwise useful book. The unfortunate thing is that the continued misrepresentation of the facts about the skeletal remains will make it more and more difficult for

students to distinguish the truth. I very much doubt that some of the authorities credited in the preface for checking the manuscript accept the statements and reasoning to which I am taking exception.

T. D. STEWART
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HUMAN FERTILITY AND PROBLEMS OF THE MALE. By EDMOND J. FARRIS. The Author's Press, xvi, 211 pp., 1 color plate, 40 tables, 33 figs. White Plains, N. Y., 1950 (\$5.00).

It hardly needs saying to readers familiar with the literature on human fertility (under which, of course, Dr. Farris includes infertility as well) that this is a subject of great general interest and of exceedingly wide ramification. But it may be something of a surprise, as it was to me, to discover that infertility is a far greater disability in the general population than is commonly supposed. Dr. Farris' calculation and experience suggest that as many as 60% of the 36,474,000 married couples of the United States are faced with some degree of this potential problem if they desire children. In the light of his records, which indicate that infertility in married couples is traceable to the wife in only about one-third of the cases, it becomes evident that the problem is chiefly centered on the male. This book, then, is mainly concerned with the factors affecting male fertility, to be followed later by another on the female.

Dr. Farris, beginning his series of studies with an investigation of the ovulation cycle in women, has been led to extend them into the various aspects of fertility and into the complicated field of application. The results of his work have enabled him to help with a high degree of success the couples who have come to him for advice. His method of rendering such help and his reasons for the procedures recommended constitute the substance of this excellent book which accomplishes the difficult feat of dealing with a complex scientific subject in simple language readily accessible to any moderately literate reader.

An essential feature of Dr. Farris' method is the precise determination of ovulation time. Since he found that the receptivity of the ovum is short lived — perhaps only a matter of hours — and that the ability of the spermatozoon to fertilize it is also of short duration, the timing of coitus with ovulation was necessary to success. Ovula-

tion is predicted on the basis of the rat hyperemia test (devised by Farris and his co-workers). Ninety per cent of the tests show that conception took place only at the time predicted.

An equally important datum in determining the advice to be given is the semen analysis upon which the classification of the male on a scale of fertility is based. Here too Farris has introduced new concepts in evaluating male fertility. Among the more important characteristics of the semen sample which directly affect the chances of conception are the relative proportion of active to inactive spermatozoa, the total number of active spermatozoa, the rate of progress and type of movement exhibited by the spermatozoa, and the proportion of normal cells. Some degree of correlation was found to exist among these variables. Usually a high count of active spermatozoa, rapid forward movement, a large proportion of normal and active cells were found to co-exist, with the opposite trends similarly conjoined. Eighty million active cells in the total ejaculate was determined to be the minimum for conception. Thus males with 80 to 185 million were classed as relatively fertile, those with 185 million and over as highly fertile and those with less than 80 million as sub-fertile. These analyses are based upon samples taken after 5 days of abstinence.

Since the frequency of intercourse affects the total count of active spermatozoa, the procedure recommended for each case varies with the fertility classification.

Artificial insemination, both as an indicated course when fertility is low or absent and in its technical aspects, is dealt with as part of the general problem of infertility. As a good book should, *Human Fertility* suggests a number of interesting possibilities for further research. It goes without saying that Dr. Farris is to be congratulated.

HARRY L. SHAPIRO

American Museum of Natural History

EXTERNAL MORPHOLOGY OF THE PRIMATE BRAIN. By CORNELIUS J. CONNOLLY. Charles C Thomas, Springfield, Illinois, xiii + 378 pages, 16 tables, 343 illustrations, 1950 (\$10.00).

For the most part this is a detailed presentation, by description, photograph, and line drawing of the fissural pattern and convolutions of the primate brain. Over 1000 hemispheres, representing species

from lemur to man inclusive, were studied. Unfortunately, medial surfaces were available for study in but a few instances.

Individual variation in fissural pattern of the lateral surfaces is clearly evident in every species and becomes relatively enormous in human brains. Nevertheless the author justifiably concludes that this complexity is superimposed on a basic pattern, a pattern which he traces through the series of primate forms. Furthermore, studies of fetal brains indicate that the pattern originates as a result of intrinsic forces and that if mechanical factors are important they act only in a secondary fashion. The number of specimens studied and the detailed data presented are just what makes this a valuable contribution. And it should be especially valuable in comparative studies, particularly those which attempt to correlate structure and function with external form.

Various measurements were made on anthropoid and human brains. Some of these are said to show that there is a pronounced symmetry in the two hemispheres of anthropoid brains, whereas in human brains the left hemisphere is larger in a greater percentage of cases. The implication is that this asymmetry is associated with cerebral dominance and handedness. But this reviewer doubts that the differences reported are significant. For example, in a large group of Negro and White (German) males, the left hemisphere was on the average but 1 mm longer than the right. Nor do the percentages reported (Negro: Right hemisphere longer in 32.4% of cases, left, 40.5%, equal, 27.1%) correspond closely to percentages relating to handedness. Any measurements of this type must be viewed with considerable reservation unless the material has been fixed in exactly the same manner and stored by a method which prevents the brains from lying on either hemisphere.

The few attempts at relating cytoarchitectonic areas and sulci seem out of place. Recent work, such as that by Lashley and Clark, indicates how difficult it is to find objective criteria by which one can parcel out the cerebral cortex on the basis of cytoarchitectonic patterns. Whether intended to or not, existing maps carry with them the implication of functional correlation and if inserted into a work of the present type, simply abet this modern phrenology.

These criticisms, however, relate to but a relatively small part of the work. The greater part of it is obviously of tremendous value and should serve as a source book for years to come.

ERNEST GARDNER
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RADIOGRAPHIC ATLAS OF SKELETAL DEVELOPMENT OF
THE HAND AND WRIST. By W. W. GREULICH AND S. I. PYLE.
Stanford University Press, 1950, xiii + 190 pp., (\$10.00).

This atlas is the successor to the well-known Todd ('37) *Atlas of Skeletal Maturation (Hand)*. It has been carefully prepared and handsomely printed, and contains 28 male and 27 female radiographic standards showing, at various intervals between birth and 18 years, the progressive skeletal maturation of hand and wrist.

The atlas also contains a section describing in detail the sequences of changes which normally occur during childhood in the shape of individual bones and epiphyses of hand and wrist, as seen in the x-ray film. These "maturity indicators" permit a more precise evaluation of skeletal status. There is also an illustration of a graphic method of studying variability of skeletal maturation, by examination of the range between the fastest and slowest maturing centers of ossification appearing at a given age.

The standards are based on the analysis of the complete Brush Foundation series of well-circumstanced children, from Cleveland families "somewhat above the average in economic and educational status." The standards reflect this selection, and appear to be advanced, even beyond the original Todd atlas. As a consequence, a less well-endowed though essentially normal child may suffer, so to speak, by comparison. In such cases it may be advisable, as the authors suggest, to scale the standards accordingly. The section entitled "What constitutes a significant deviation from normal" should be read carefully in order to use the atlas most effectively.

The quality of the original films, and of their reproductions, are both important factors in determining the usefulness of any skeletal atlas. The present atlas fares very well in this regard. The hand-films for the older children are, as might be expected, somewhat better in quality than those taken on the infants. There are also some differences in individual reproductions, even at adjacent age-levels; for instance, male Standard No. 7 ($1\frac{1}{2}$ years) is a better plate than No. 6 ($1\frac{1}{4}$ years). Female Standard No. 20 (12 years), to take another instance, is definitely superior in quality to No. 19 (11 years). As a whole, however, the quality of the radiographic standards shows a marked improvement over those in earlier atlases.

The intervals between the various standards are not regularly spaced, nor do they entirely coincide for the sexes. For example, the 6, 7 and 8 year standards for the boys are the equivalent chronologically of the 5 $9/12$, 6 $10/12$ and 7 $10/12$ year standards, respectively, for the girls. The authors have discussed these differences, and feel that "the advantages of standards which portray continuous, well-

balanced skeletal development will be found to outweigh whatever disadvantages the lack of a uniform time interval between successive standards might produce." It is fruitless to discuss the merits of this argument in a review; time and the use of the atlas will tell whether the authors' decision was justified. In passing, it should be mentioned that male Standard No. 9 gives an age of 2 years, 6 months on page 52 and an age of 2 years, 8 months on page 53.

Somewhat more serious, perhaps, is the matter of the length of intervals between standards. After the age of 5 years, except for an additional standard for boys at 15½ years, and for girls at 13½ years, the standards are spaced at approximately yearly intervals. (However, because of the decision discussed in the preceding paragraph, there is, for example, an interval of 18 months between male Standards No. 20 and 21, and only 9 months between No. 21 and 22.) Yearly intervals are satisfactory, in the opinion of the reviewer, between the ages of 5 and 12 years, and 16 and 18 years, for the boys, and between the ages of 5 and 10 years, and 15 and 18 years, for the girls. However, between 12 and 16 years for the boys, and between 10 and 15 years for the girls, I believe the value of the atlas would have been considerably increased by the inclusion of additional half-yearly standards. For instance, the inclusion of a single intermediate standard for the girls, at 13½ years, does not adequately meet the need, since at least half the white female population of this country have already reached menarche by this age, and the active skeletal processes accompanying sexual maturation have already been going on for several years.

The value and interest of the atlas is enhanced by the inclusion of sections discussing the relation of skeletal development to such factors as normal sexual development, precocious puberty, hypogenital states and effects of illness. The authors' discussion of the values and limitations of the assessment of hand-films is sound and well-expressed. It is true that, in most cases, the hand provides a reliable index to the state of skeletal development of the body. In a study of this problem, the reviewer has found that, for children three years of age and younger, between 60% and 70% of the ratings made on the hand gave a classification of skeletal status identical with that obtained from the roentgenograms of the whole body; between 30% and 35% of the ratings agreed satisfactorily; and only about 2% of the hand ratings were completely unrepresentative of the skeletal status of the body.

The authors of this atlas are to be congratulated on the successful completion of a task requiring several years of tedious and meticulous research. Their contribution will be a valuable tool, both to the

clinician and to the research worker, in the assessment of skeletal development in children.

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BONE AND JOINT DISEASES. By J. VERNON LUCK. xiii + 614 pp. Charles C. Thomas, Springfield, Illinois, 1950. \$16.50.

Physical anthropology, which concerns itself so extensively and intensively with skeletal material of man, is constantly confronted with a great variety of problems which belong properly in the domain of human pathology. In describing series of skeletons or fossil finds anthropologists have to distinguish first of all the normal from the abnormal and can add much of value by recording also the kind and incidence of any pathological conditions encountered. Anthropologists, furthermore, can learn much of value in their own studies from the profound experiments nature performs in changing and adjusting the skeleton in response to disease or injury. Here, as in so much else, anthropology must rely on expert guidance from another, specialized field of science.

There has long existed a dearth of textbooks devoted specially to the pathology of bone, at least in English. The recent book by Weinmann and Sicher on "Bone and Bones" (St. Louis, 1947) is helpful in many respects, but its section on pathology is hardly comprehensive enough, nor adequately illustrated. The volume under review, though intended for the medical profession, is highly to be welcomed by physical anthropology, as it is an up-to-date, authoritative, systematic treatise on skeletal pathology, clearly written and very generously illustrated with 454 admirably reproduced figures. The author has gone far beyond the mere description of diseased conditions by emphasizing throughout the abnormal physiological functions which produce skeletal changes, thus demonstrating the many factors capable of influencing growth, form, size, and architecture of bone, or leading to new bone formation or bony destruction.

An excellent introductory chapter deals with the normal skeletal system, discussing in general terms the embryology, anatomy, histology, chemistry, etc., of bone, cartilage and joints, as well as the physical properties of bone and the theories regarding bone formation

and bone resorption. Of the many chapters on pathology those devoted to the following subjects are of special interest to physical anthropologists: fractures; the different forms of chronic arthritis and of osteomyelitis; the skeletal manifestations of metabolic and of endocrine disorders; and congenitally defective ossification. The wealth of information presented in these chapters includes much which bears on fields of physical anthropology other than the osteological one, such as the striking effects of hyper- and hypogonadism and of hypothyroidism on general growth and body proportions. Here one encounters such information of anthropological interest as that stature decreases during senility largely due to loss in the fluid content in the nucleus pulposus of the intervertebral disks, or that the head circumference can increase from 53 to 67 cm in older patients with Paget's disease, so that they require a new hat every year.

Each chapter ends with a long list of selected references. A very detailed subject index adds greatly to the usefulness of this volume which should be within easy reach of every osteological collection.

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NEW STUDIES ON RHODESIAN MAN.—Of all the bones [from Broken Hill] tested, the cranium of *Homo rhodesiensis* alone contains more zinc than lead. This was contrary to expectations, although an unpublished record in the archives of the British Museum . . . shows that when the skull arrived at the Museum it was partly encrusted with a layer of crystalline zinc silicate, or hemimorphite. However, since the finder and the captain of the mine assert that the skull was found at the 60 ft. level, "surrounded by softer stuff" and "under pure lead ore" (these were the finder's words), the probability is that it occupied a pocket of zinc ore within a mass of friable lead carbonate. It is not improbable that there had been some natural collapse in this part of the cave, as a result of removal of zinc in solution from a mixed lead and zinc ore-body . . . , in which case there is a possibility that the skull originally occurred at the level of the clay layer with "bat" bones.

That all the human bones should contain as much lead as zinc, most of them much more, and that the matrix of some of the sig-

nificant artifacts is rich in lead, is contrary to the idea that all human limb- and other post-cranial bones, together with the artifacts, came from the higher zinc levels.

In view of its high zinc content one might now be inclined to suppose that the type skull had fallen from a higher level during mining operations. However, the maxilla of the second skull which was referred by Pycraft ('28, p. 50) to *H. rhodesiensis* shows a relatively high lead content, and so evidently came from a low level in the cave filling. The human parietal bone recovered from the mine by Hrdlička in 1925 (no. 11 in the appended table), shows the same mineral composition. It has been stated that it is of modern type, but Dr. L. H. Wells, who recently examined it, says that it is so incomplete, and may represent an immature individual, that one cannot be sure that it does not belong to *H. rhodesiensis*. One must not overlook the possibility that *Homo sapiens* may have been living in the Broken Hill region before the caves were sealed by mineralization, which was probably before the Late Stone Age according to Mr. Desmond Clark. However, the spectrographic evidence also favours a stratigraphic association of the maxilla of *H. rhodesiensis* (no. 2) with the left femur (no. 4), the sacrum (no. 6) and the male os innominatum (no. 7); and since the new data do not contradict the reported association of the type cranium with the tibia, there is little reason for doubting that at least all the human bones recovered from the cave in 1921-22 form a contemporary group. Their size and robustness are consistent with the general conclusion that they are all referable to *H. rhodesiensis*, indicating that this was a variable species with some neanderthaloid features, but straight limbed and fully erect, in some respects comparable with *Homo palestinus*, and even more so with the late Pleistocene *Homo soloensis* of Java.—Kenneth P. Oakley. Mineral evidence for the relative dating of the remains of Rhodesian man and associated material. J. Roy. Anthropol. Inst., vol. 77, pt. 1, 1947, pp. 7-11.

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